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VOLUME II

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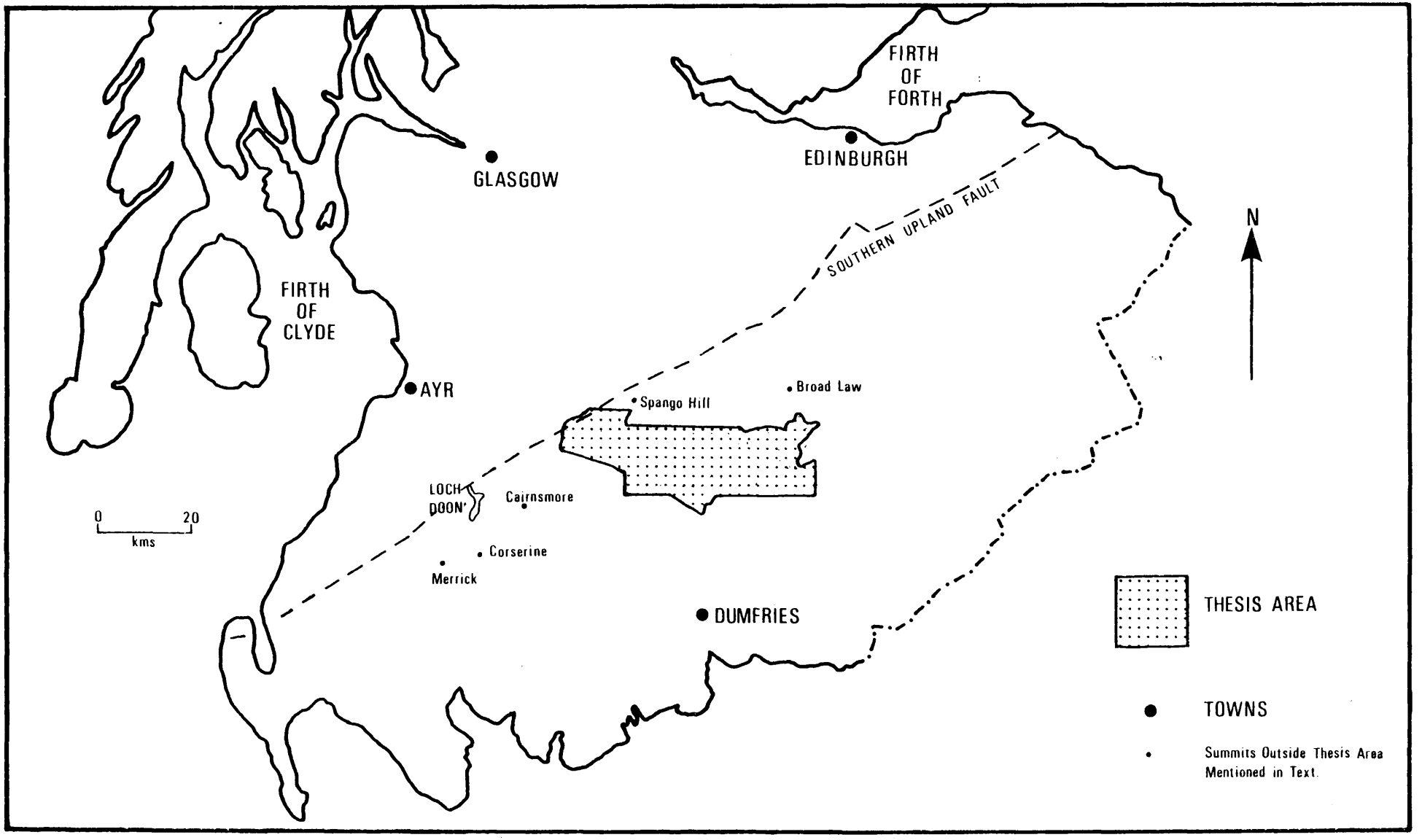


Fig. 1.1. Location of the thesis area.

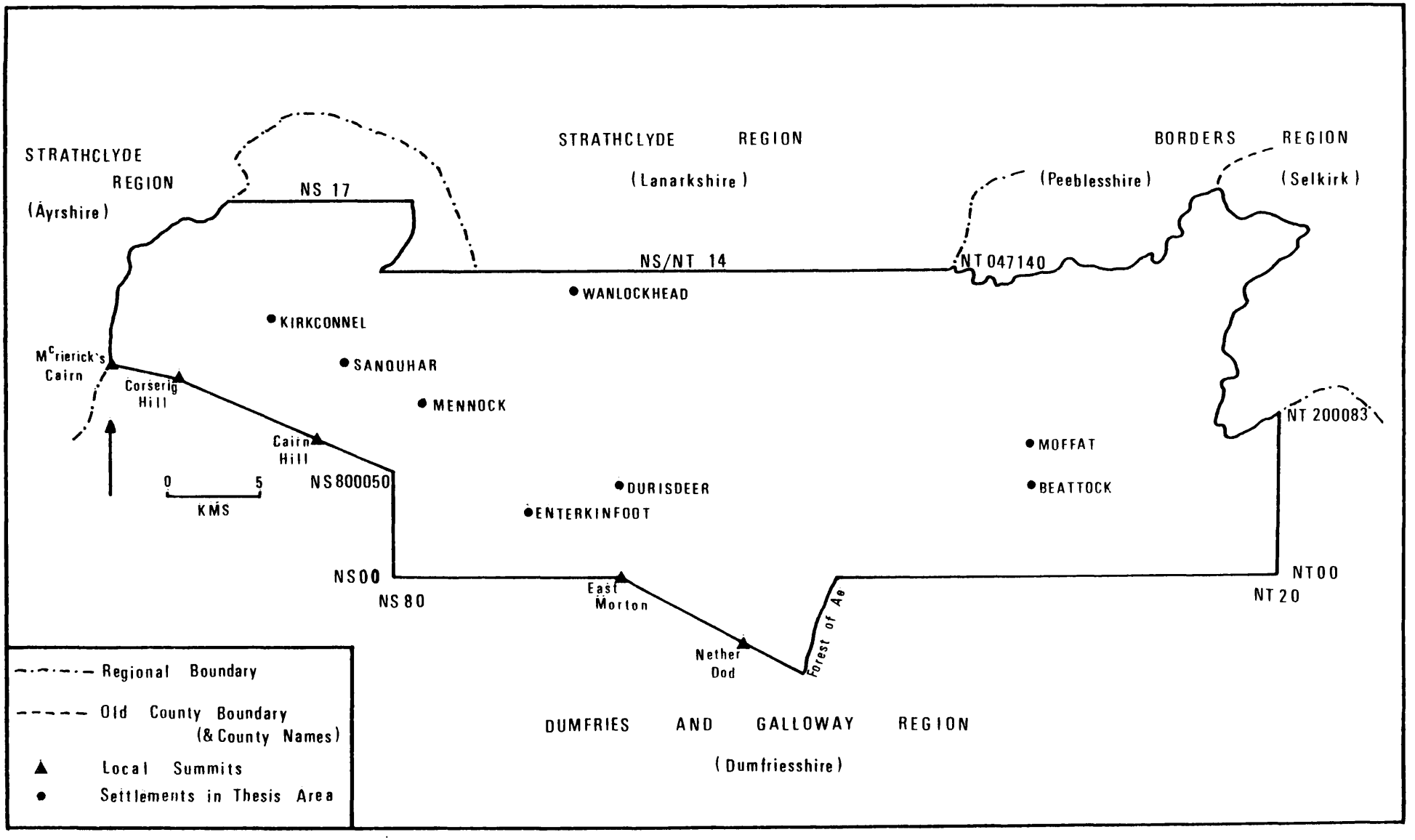


Fig. 12. Boundary lines to thesis area.

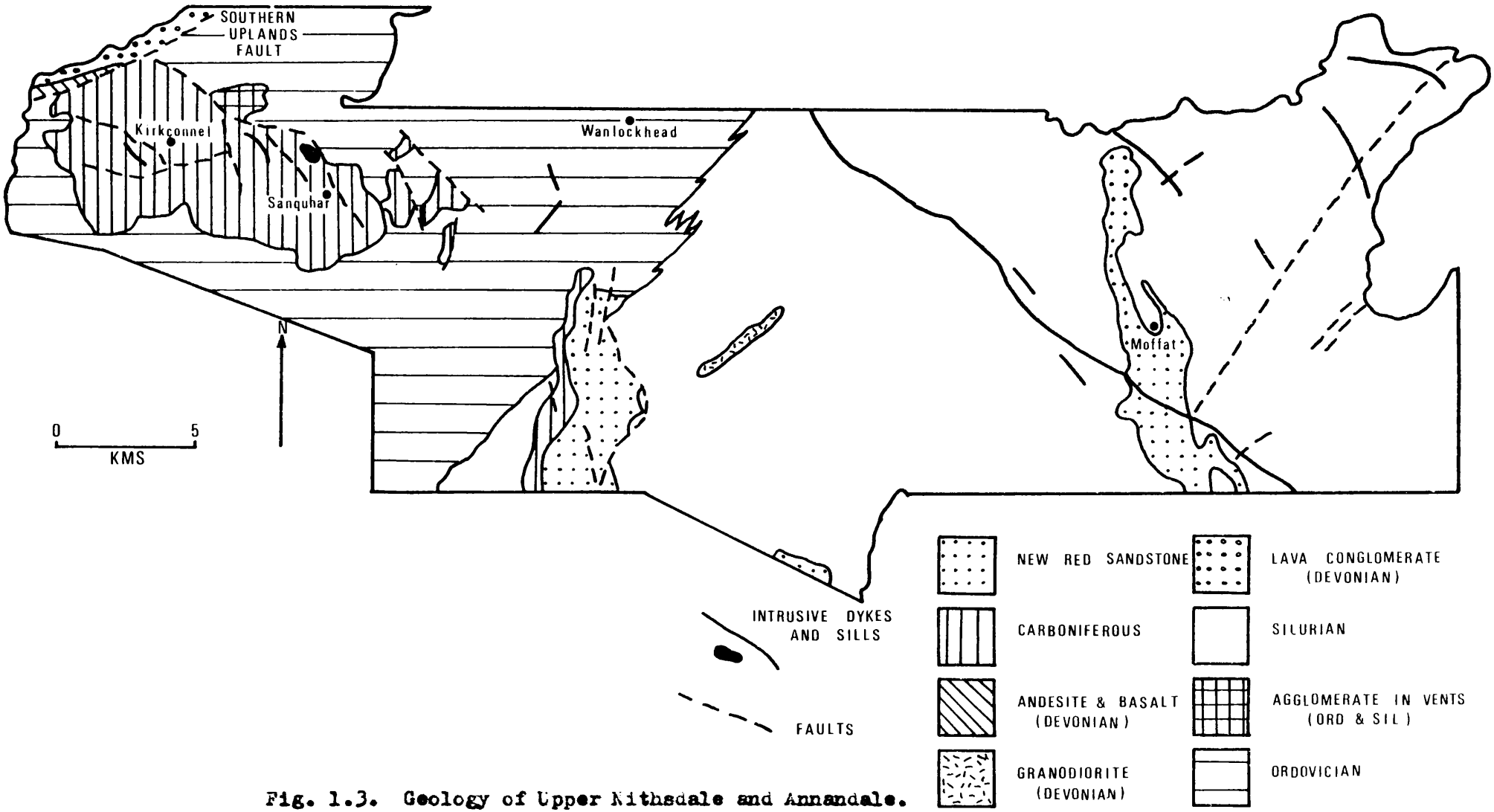
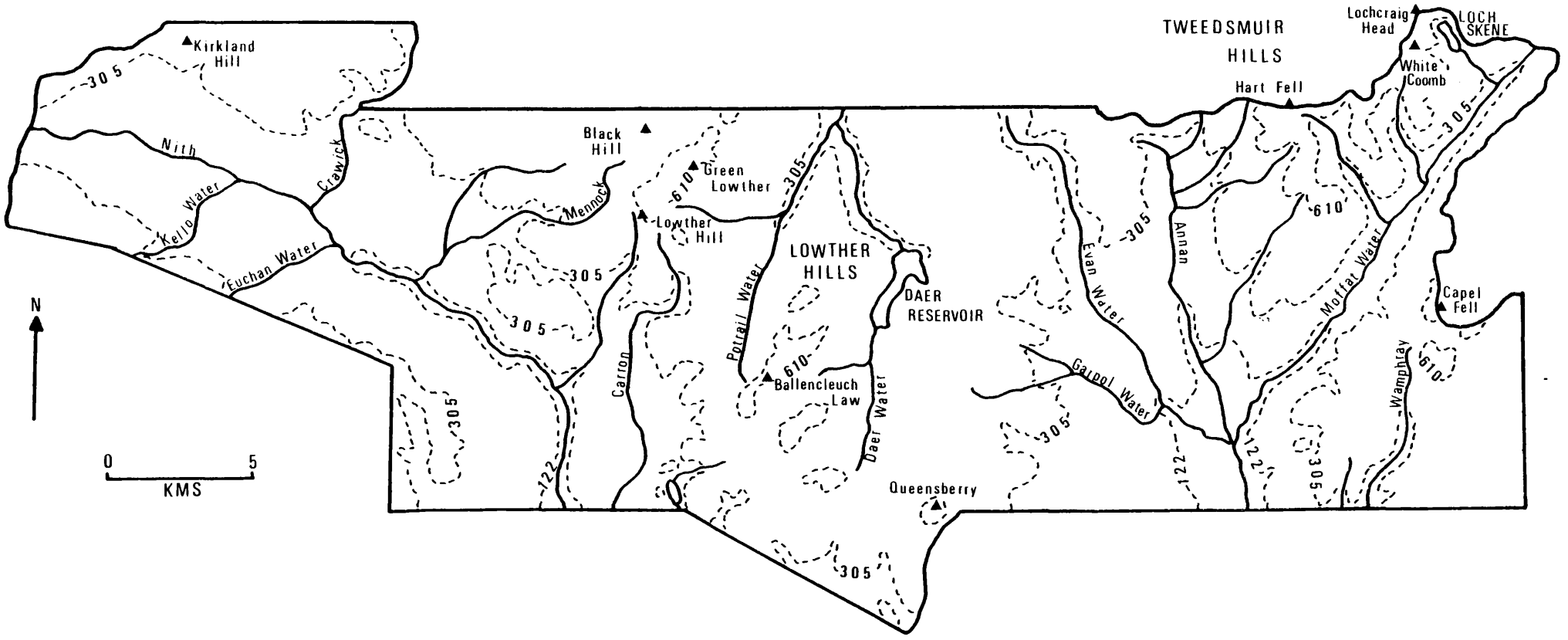


Fig. 1.3. Geology of Upper Nithsdale and Annandale.



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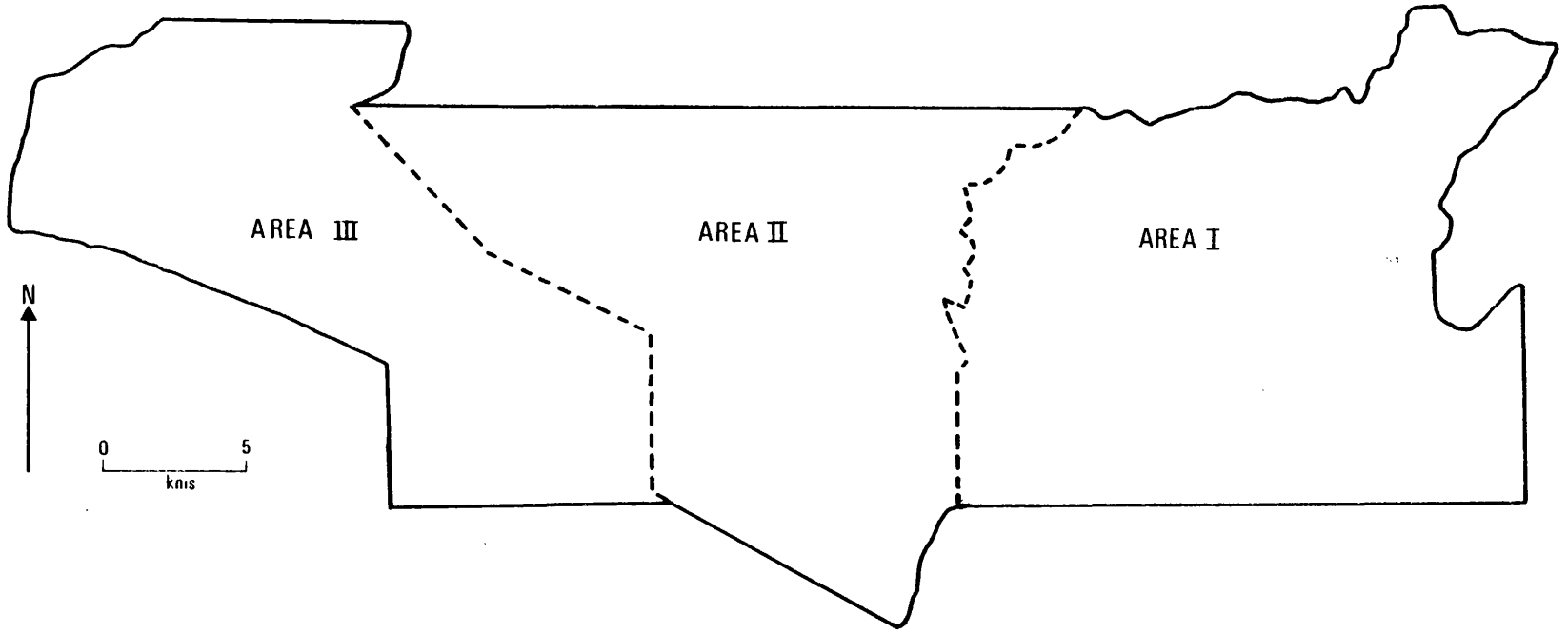

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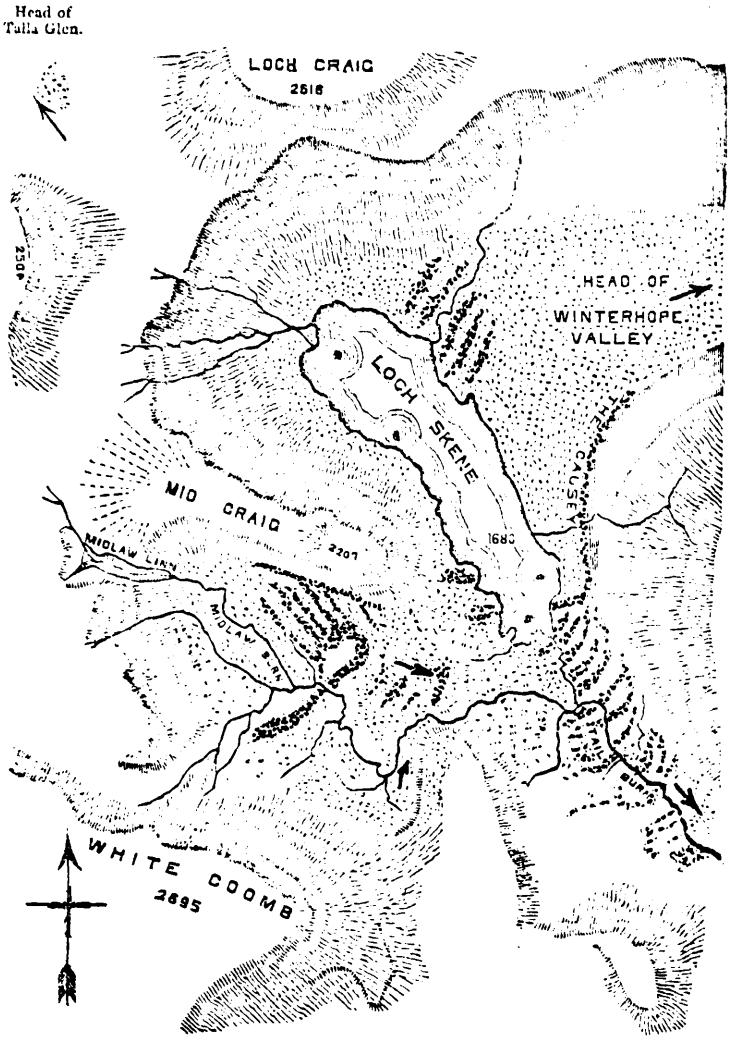

The arrows indicate the direction in which the Glaciers moved; the figures the heights above the sea.

* By Archibald Geikie, Esq., F.G.S.

Fig. 2.1. Glacier-moraines of Loch Skene - Young, 1864.

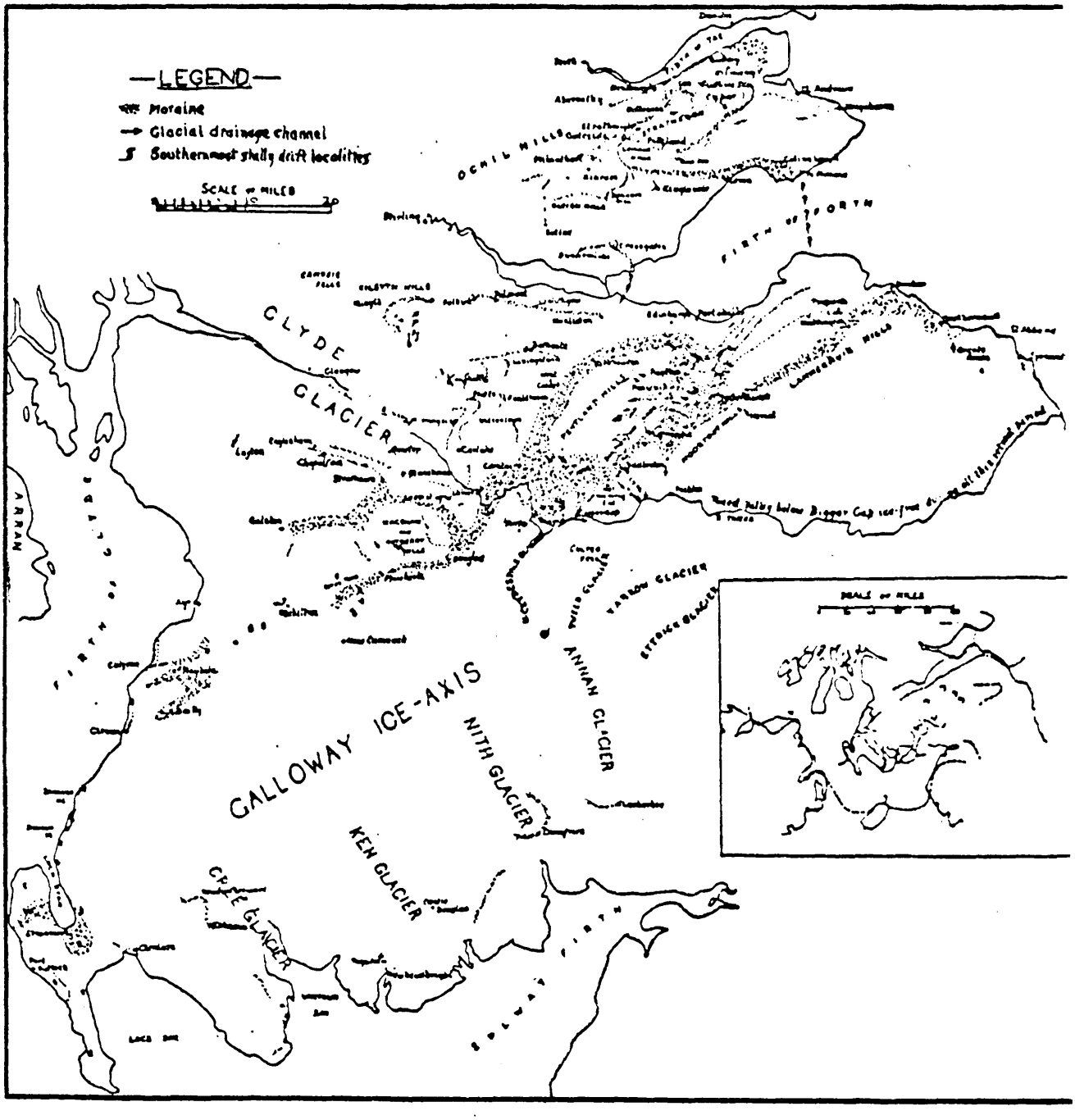

Fig. 2.2. Glaciation of Southern Scotland - Charlesworth,1926b.

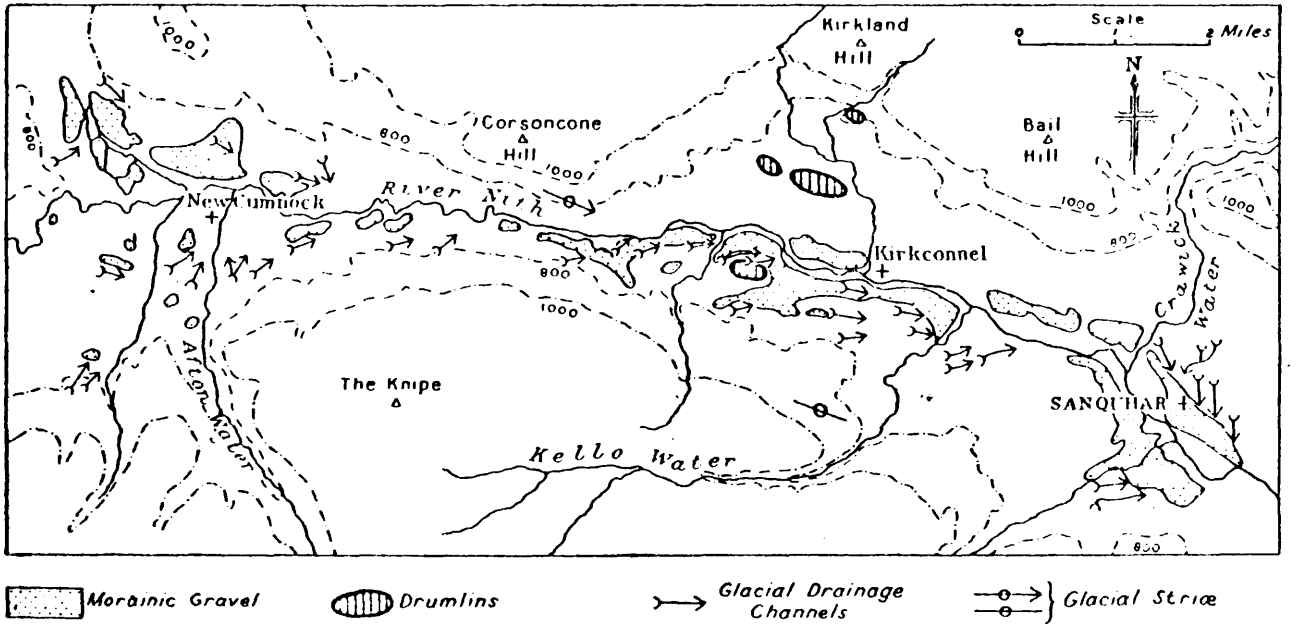

Fig. 2.3. Glacial landforms in the Nith valley between New Cumnock and Sanquhar - Simpson and Richey, 1936.

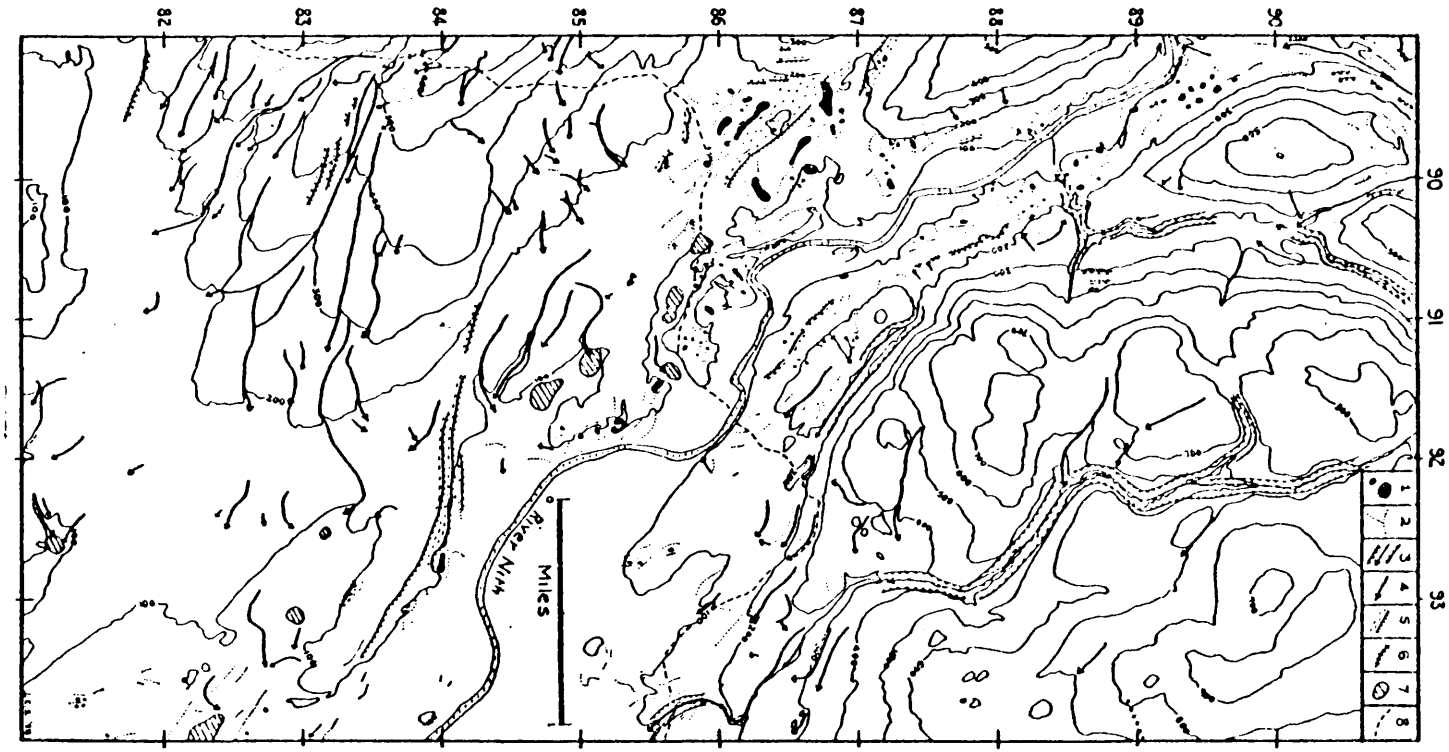

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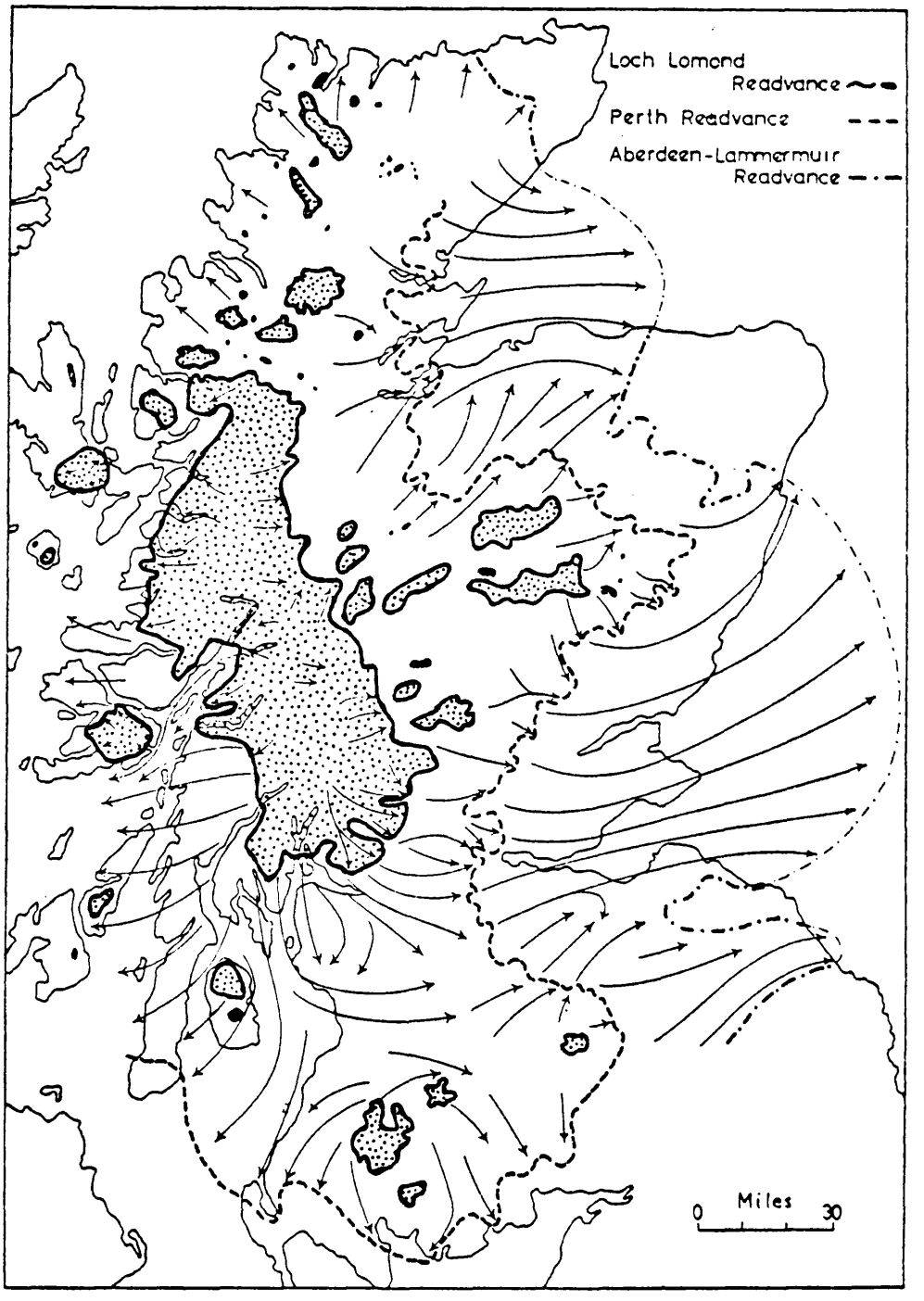
Fig. 2.4. Glacial retreat features in Mid-Nithsdale - Stone, 1959.



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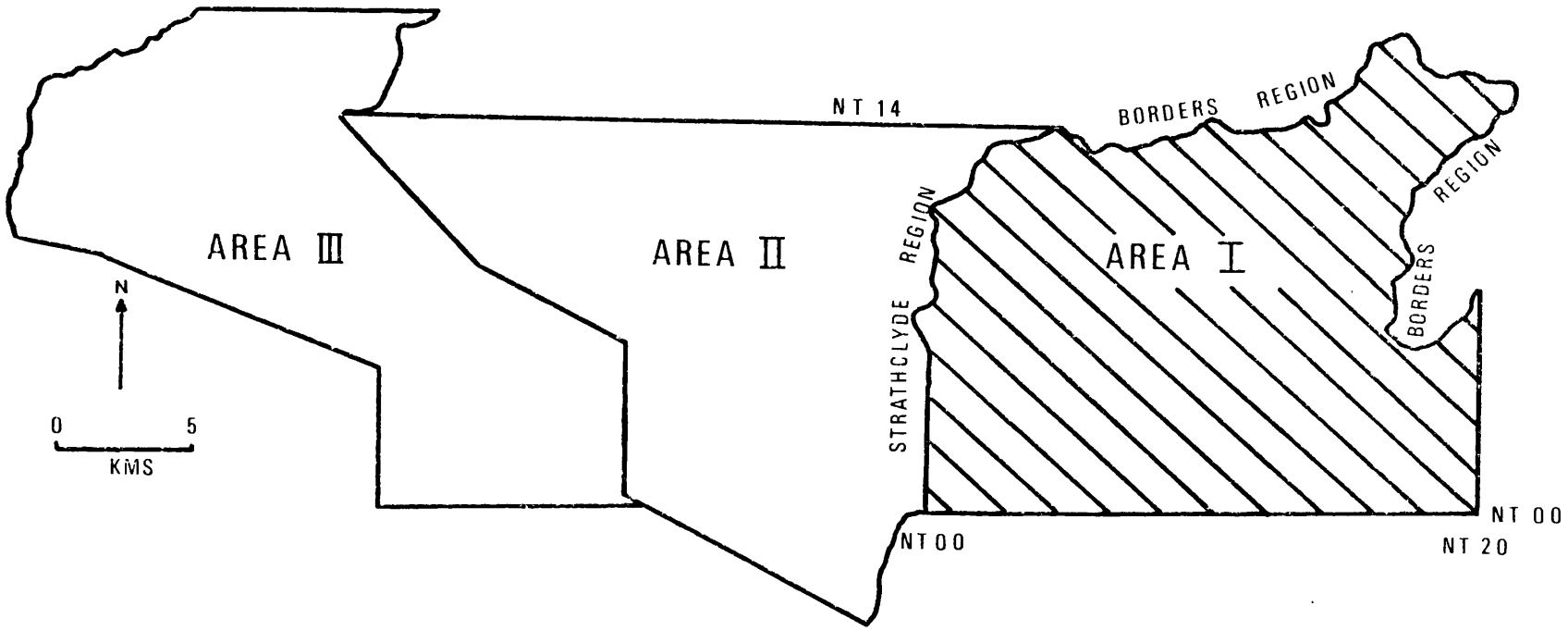
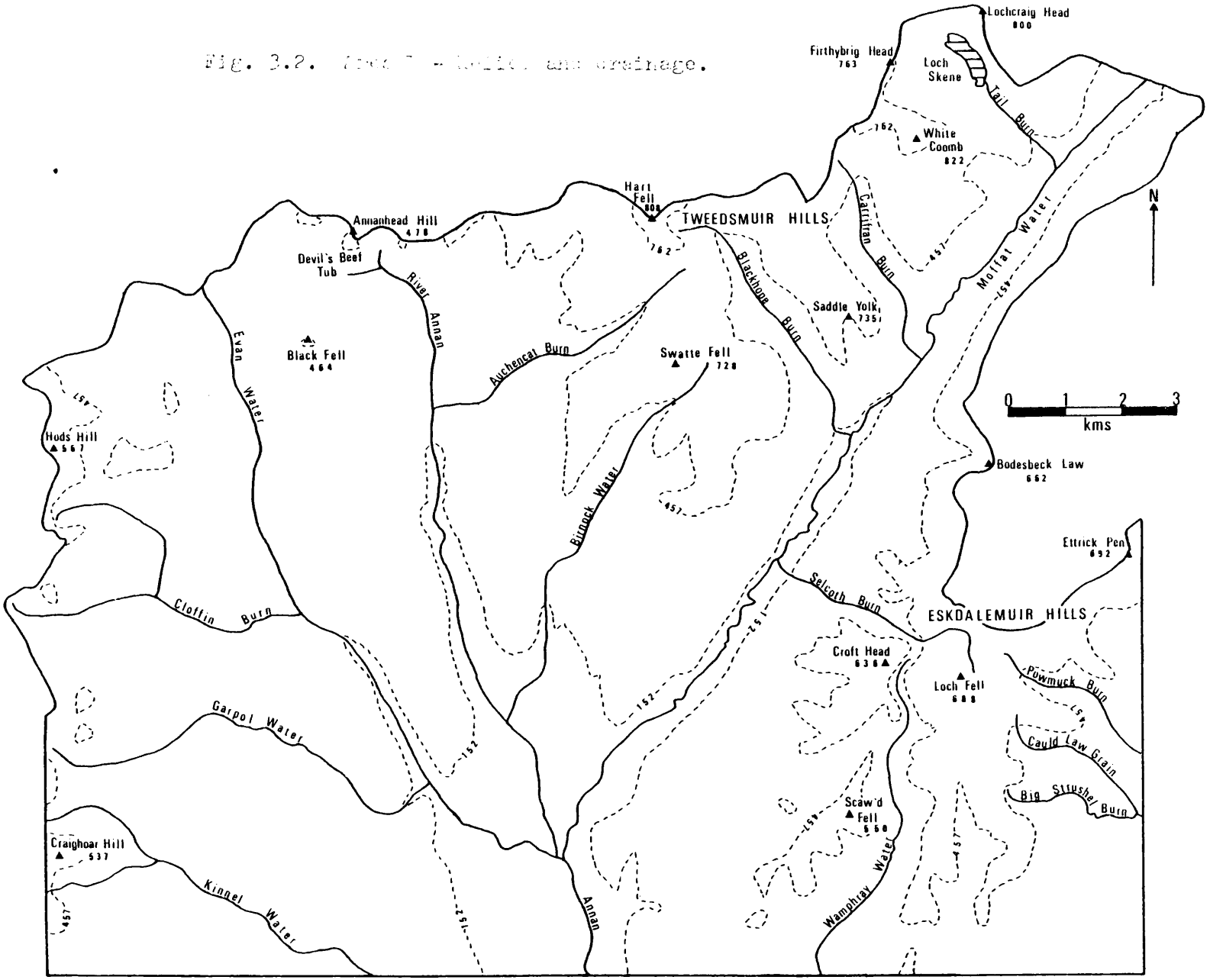


Fig. 3.1. Area 1 - Location and extent.

Fig. 3.2. [illegible] and drainage.



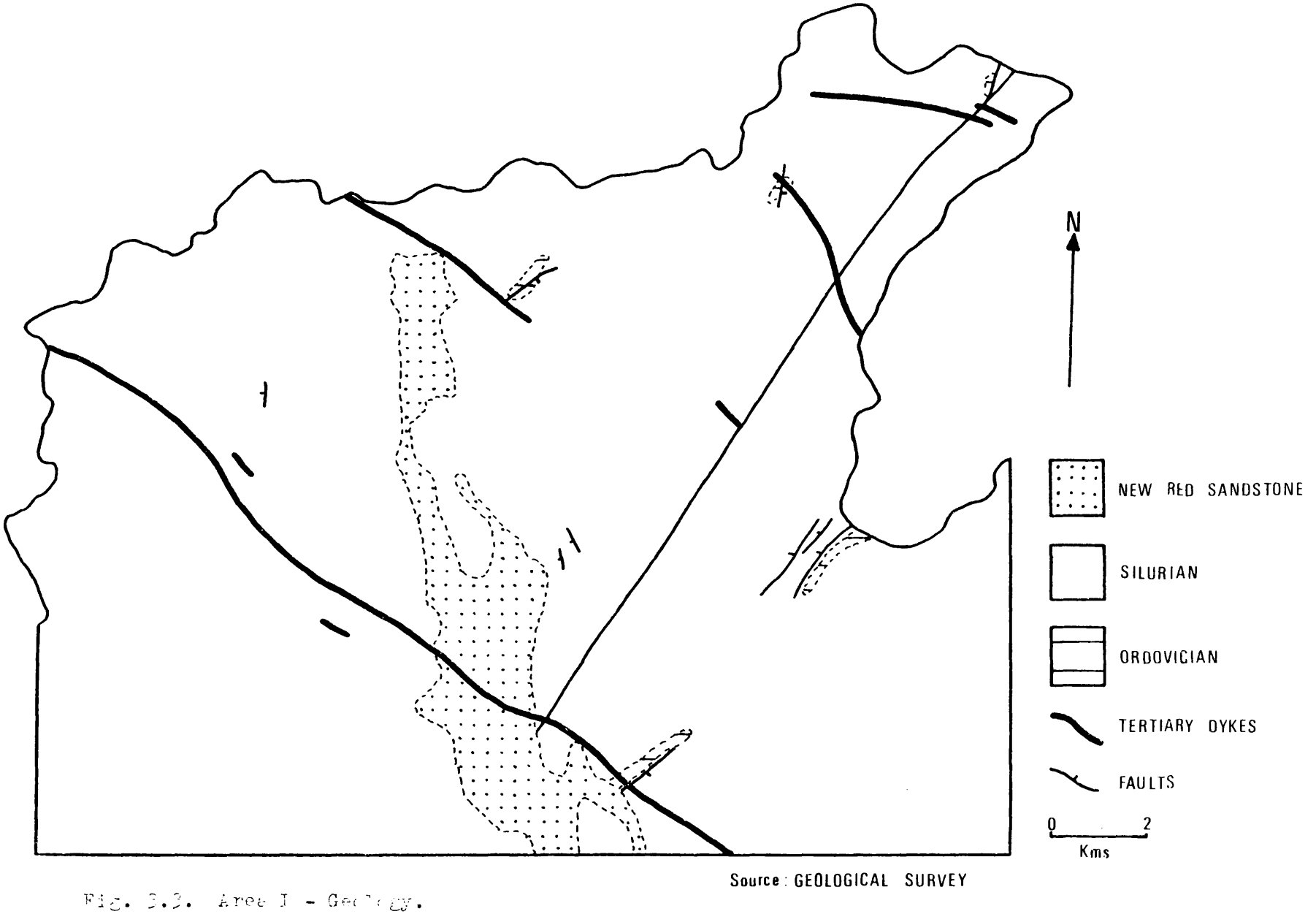
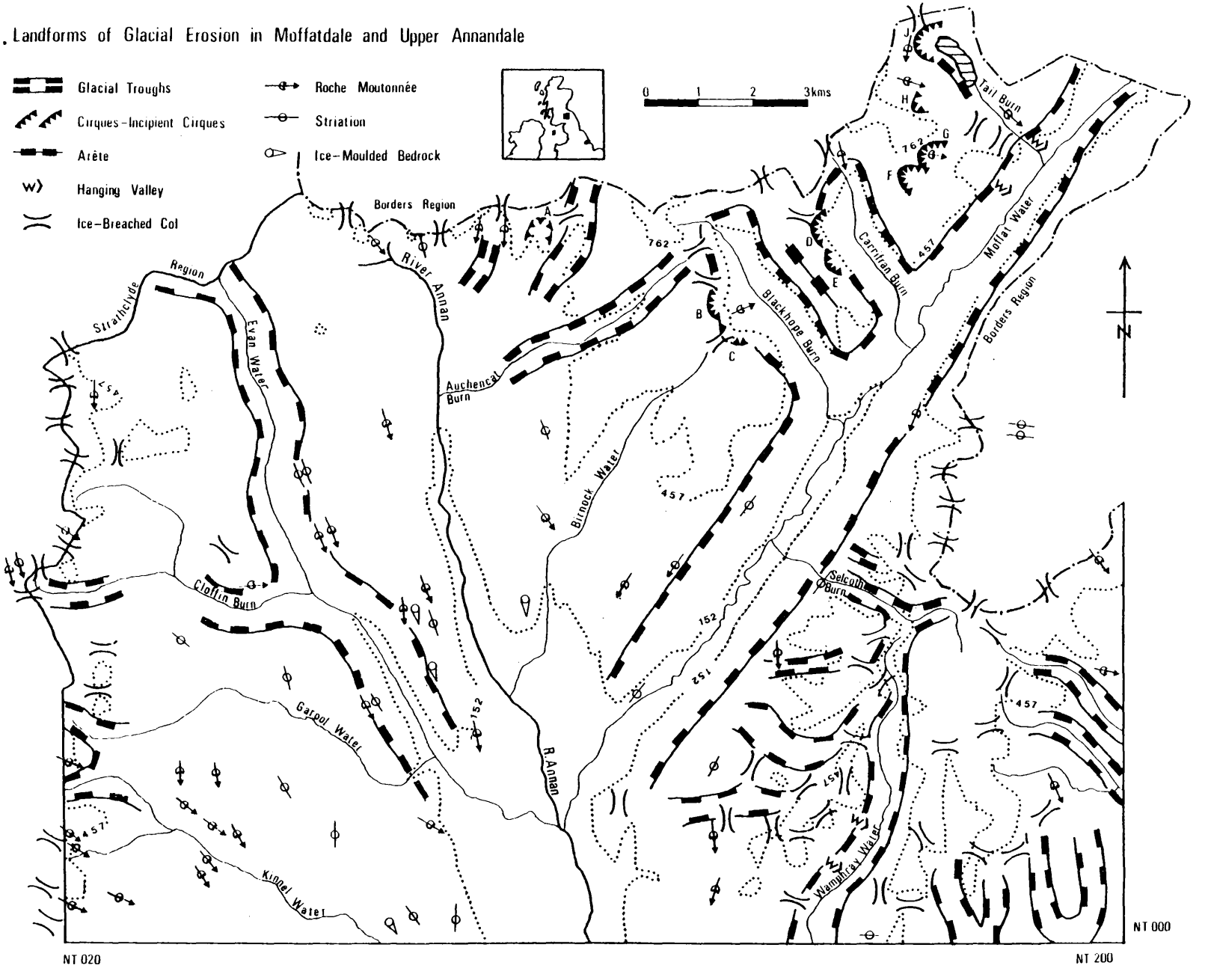


Fig. 3.3. Area I - Geology.

Landforms of Glacial Erosion in Moffatdale and Upper Annandale



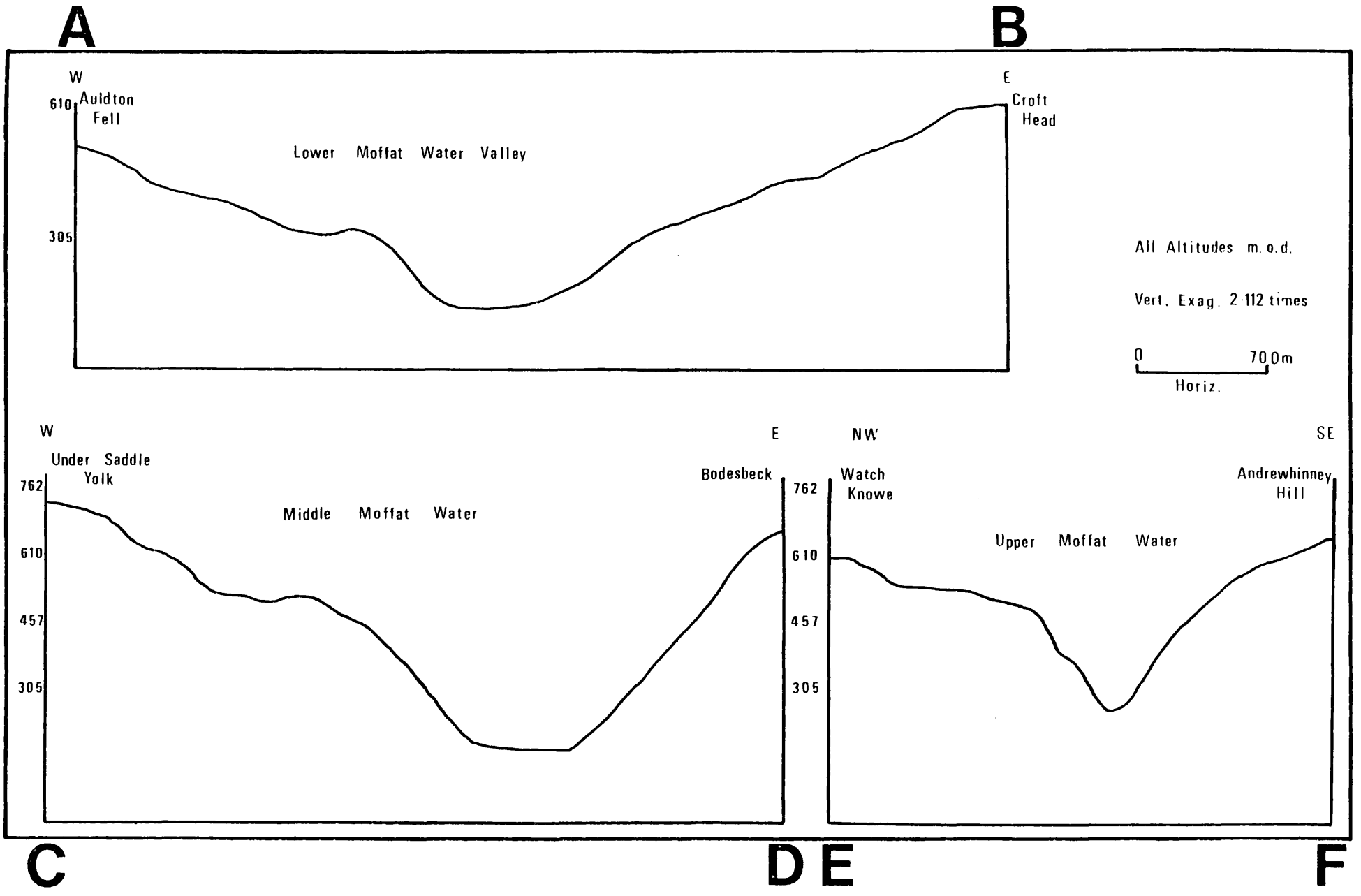

A
B
W
610
Auldton
Fell
Lower Moffat Water Valley
305
E
Croft
Head
All Altitudes m.o.d.
Vert. Exag. 2·112 times
0
700m
Horiz.
W
Under Saddle
Yolk
762
610
457
305
Middle Moffat Water
E
Bodesbeck
762
610
457
305
NW
Watch
Knowe
Upper Moffat Water
SE
Andrewhinney
Hill
C
D E
F

Fig. 3.

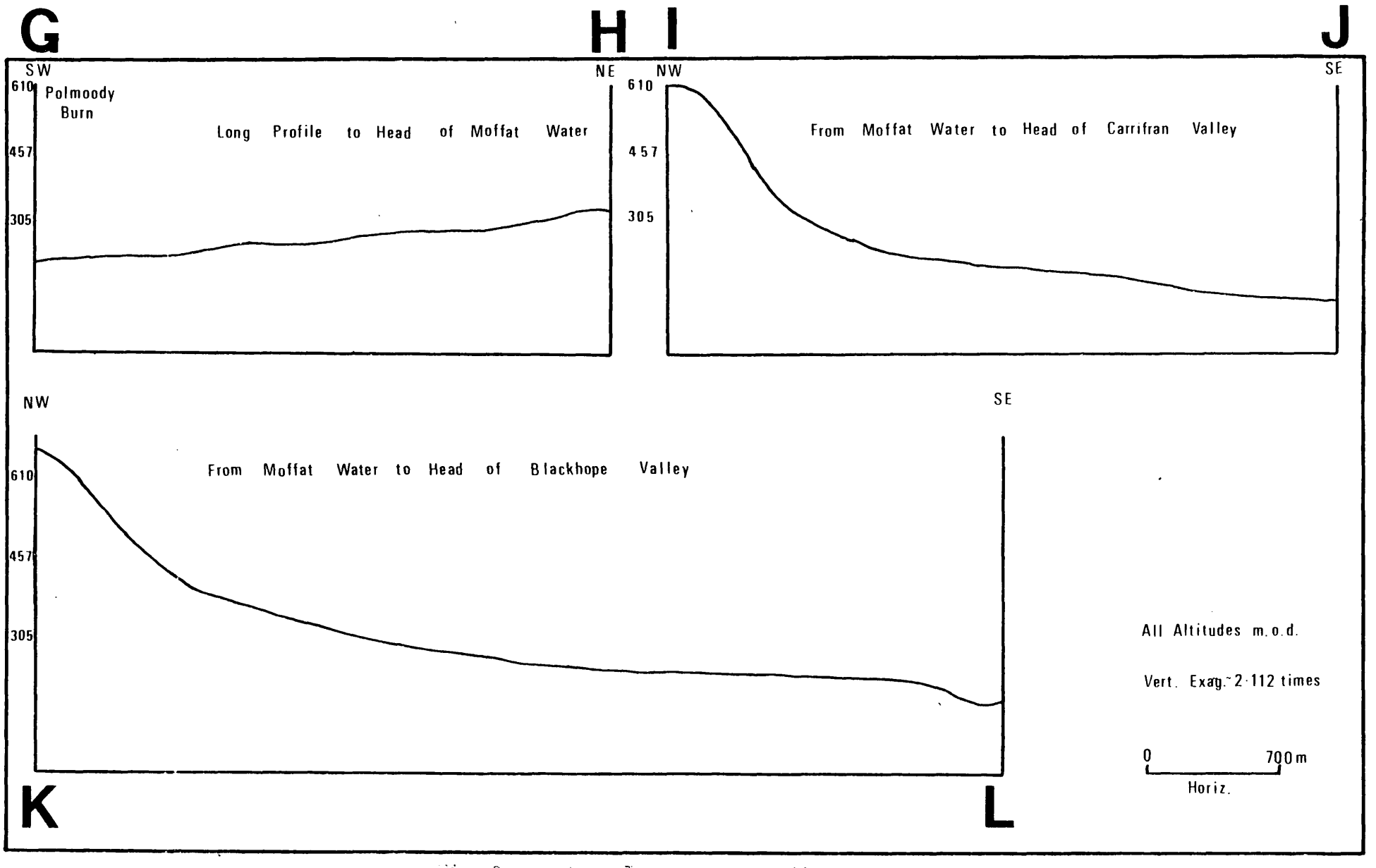
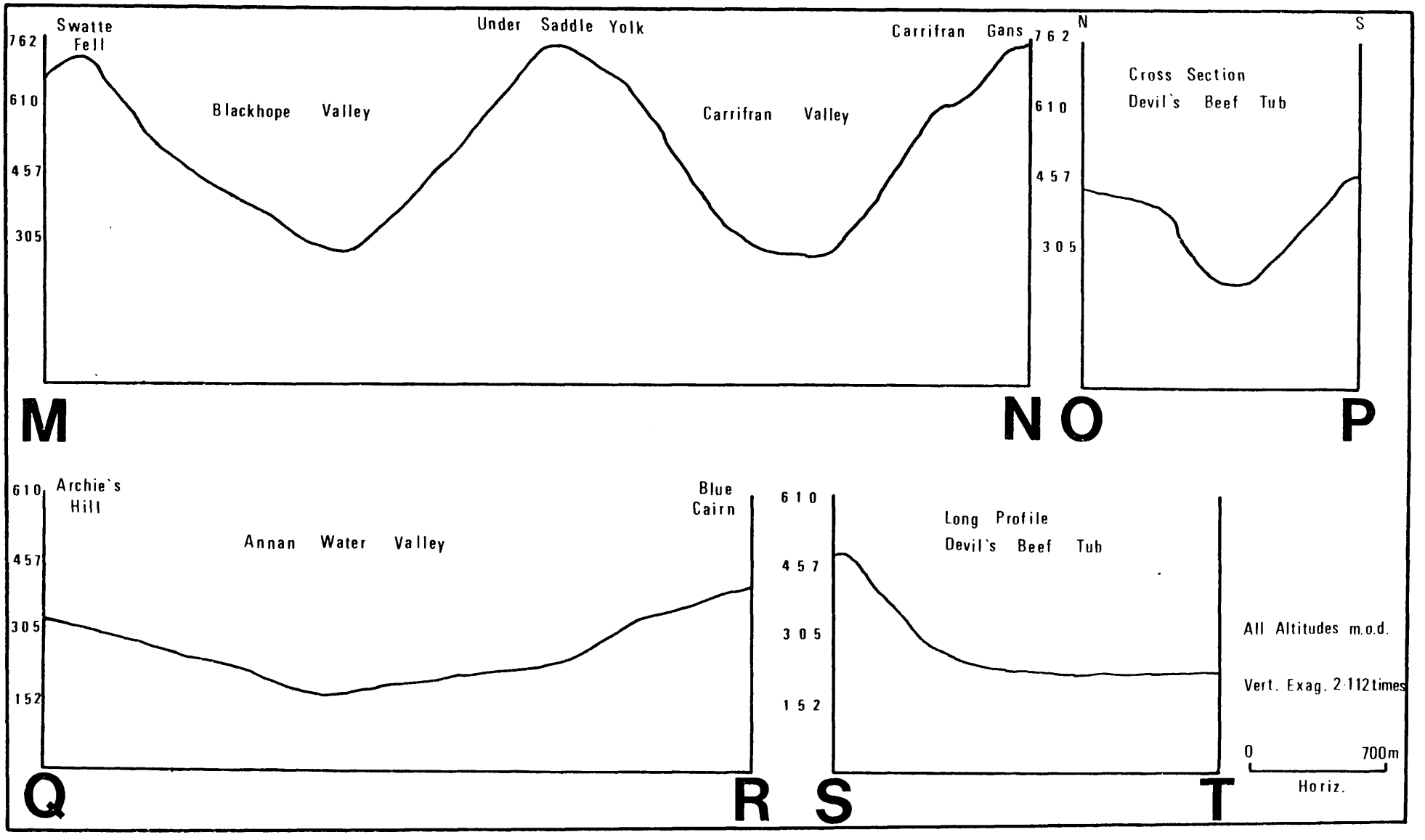
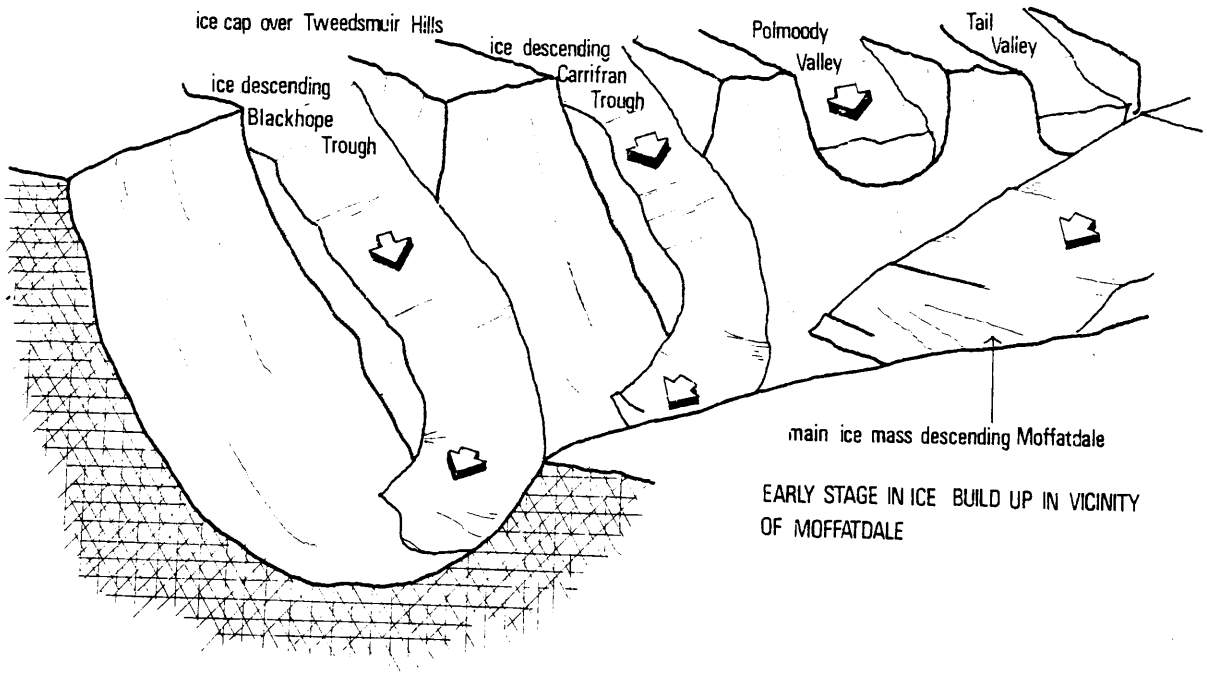


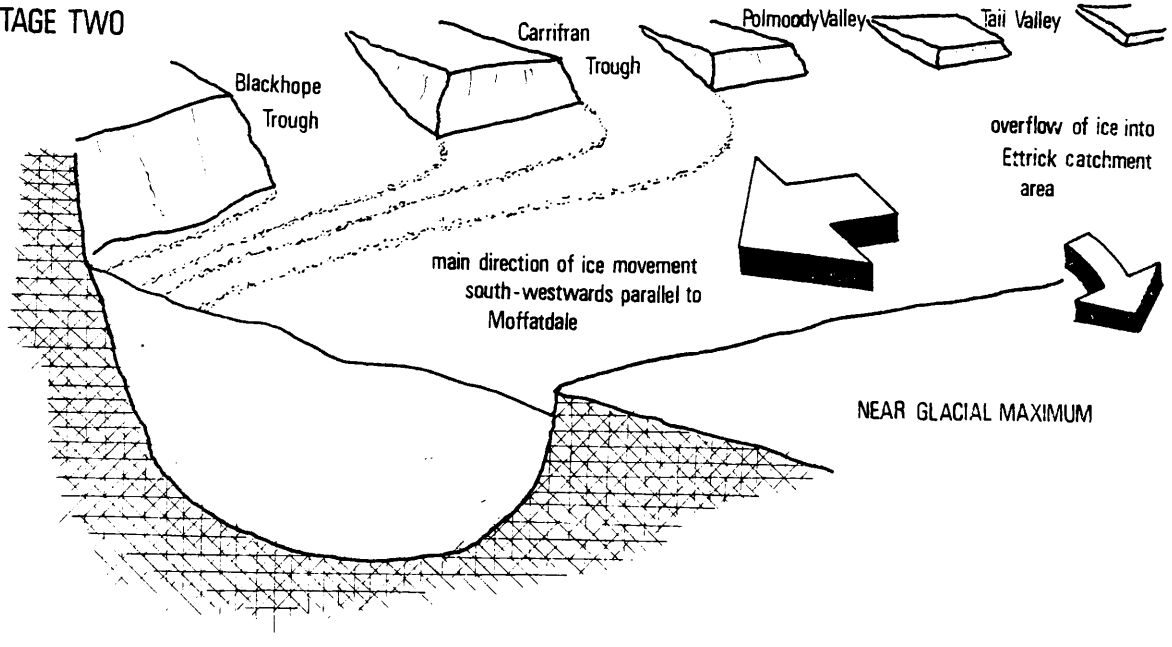
Fig. 3.6. Area 1 - cross-sections cont.


Swatte Fell
762
610
457
305
Under Saddle Yolk
Carrifran Gans
Blackhope Valley
Carrifran Valley
M
N
O
P
N
S
762
610
457
305
Cross Section
Devil's Beef Tub
610
Archie's Hill
457
305
152
Annan Water Valley
Blue Cairn
Q
R
S
T
610
457
305
152
Long Profile
Devil's Beef Tub
All Altitudes m.o.d.
Vert. Exag. 2·112times
0
700m
Horiz.

STAGE ONE



STAGE TWO



STAGE THREE

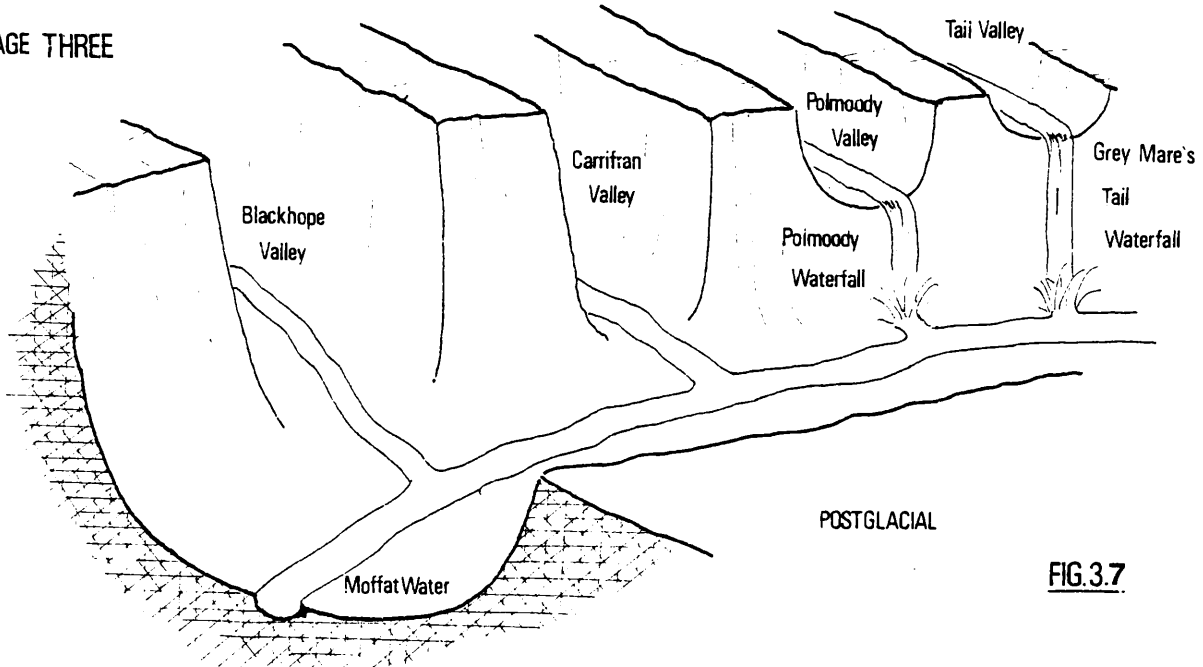


FIG.3.7

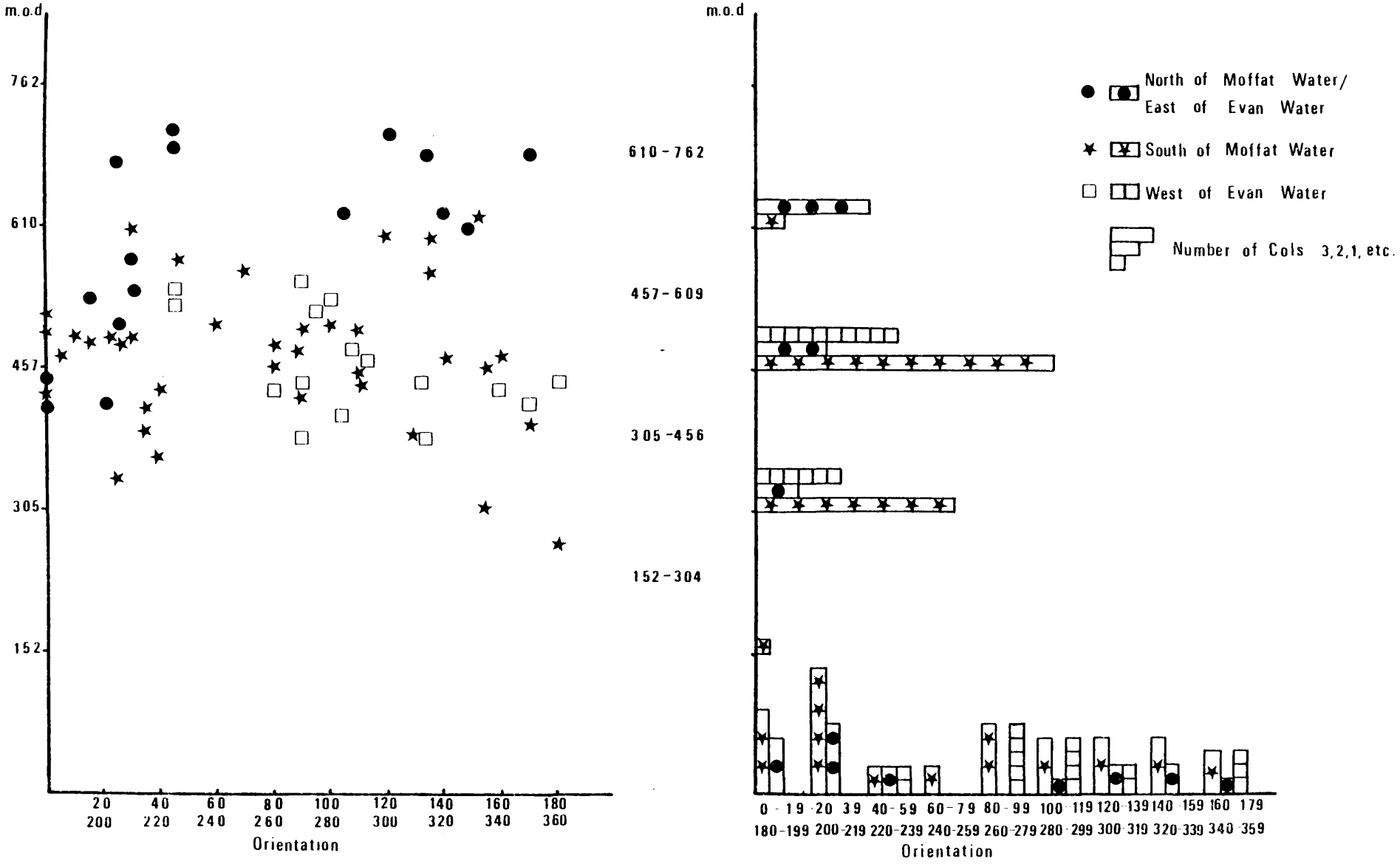


Fig. 3.8. Area I - Altitude and alignment of cols.

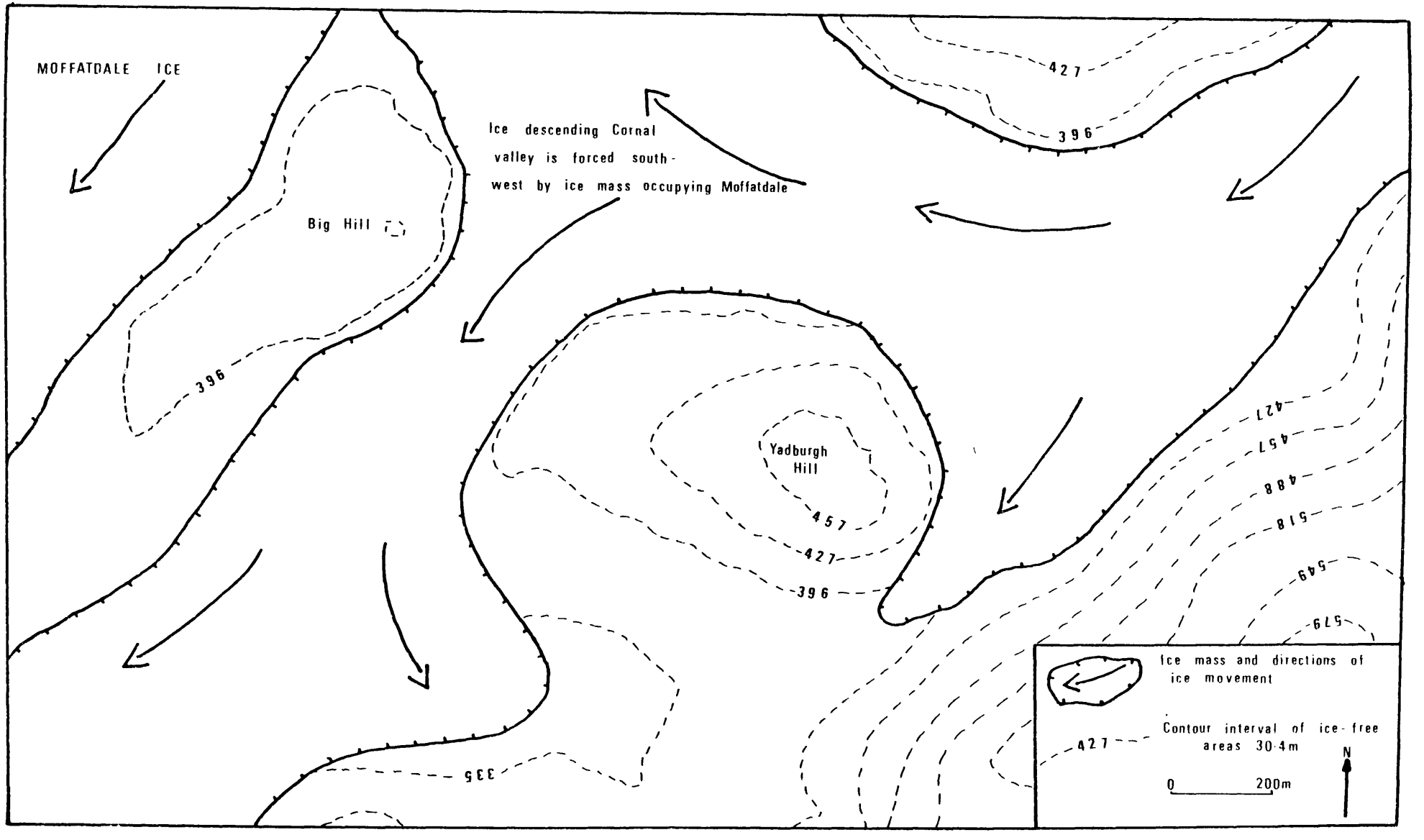
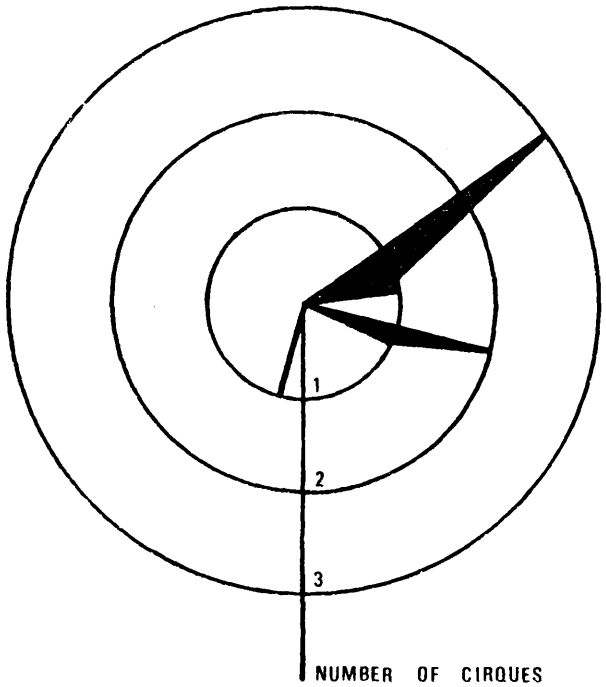
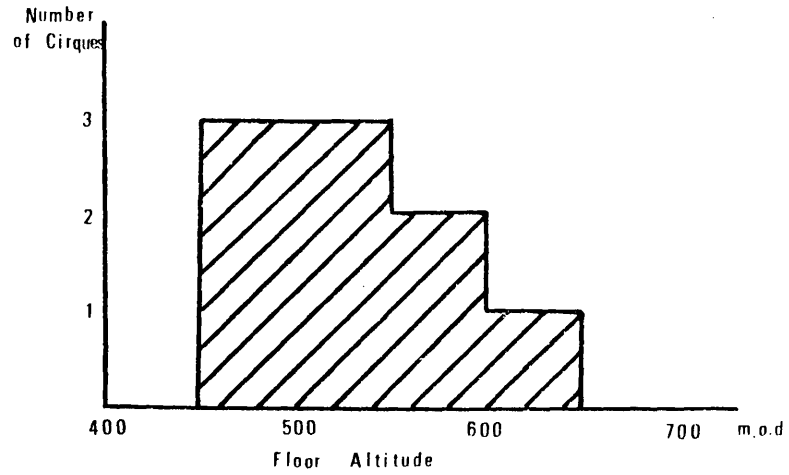


Fig. 3.9. Big Hill - Yadburgh Hill col.



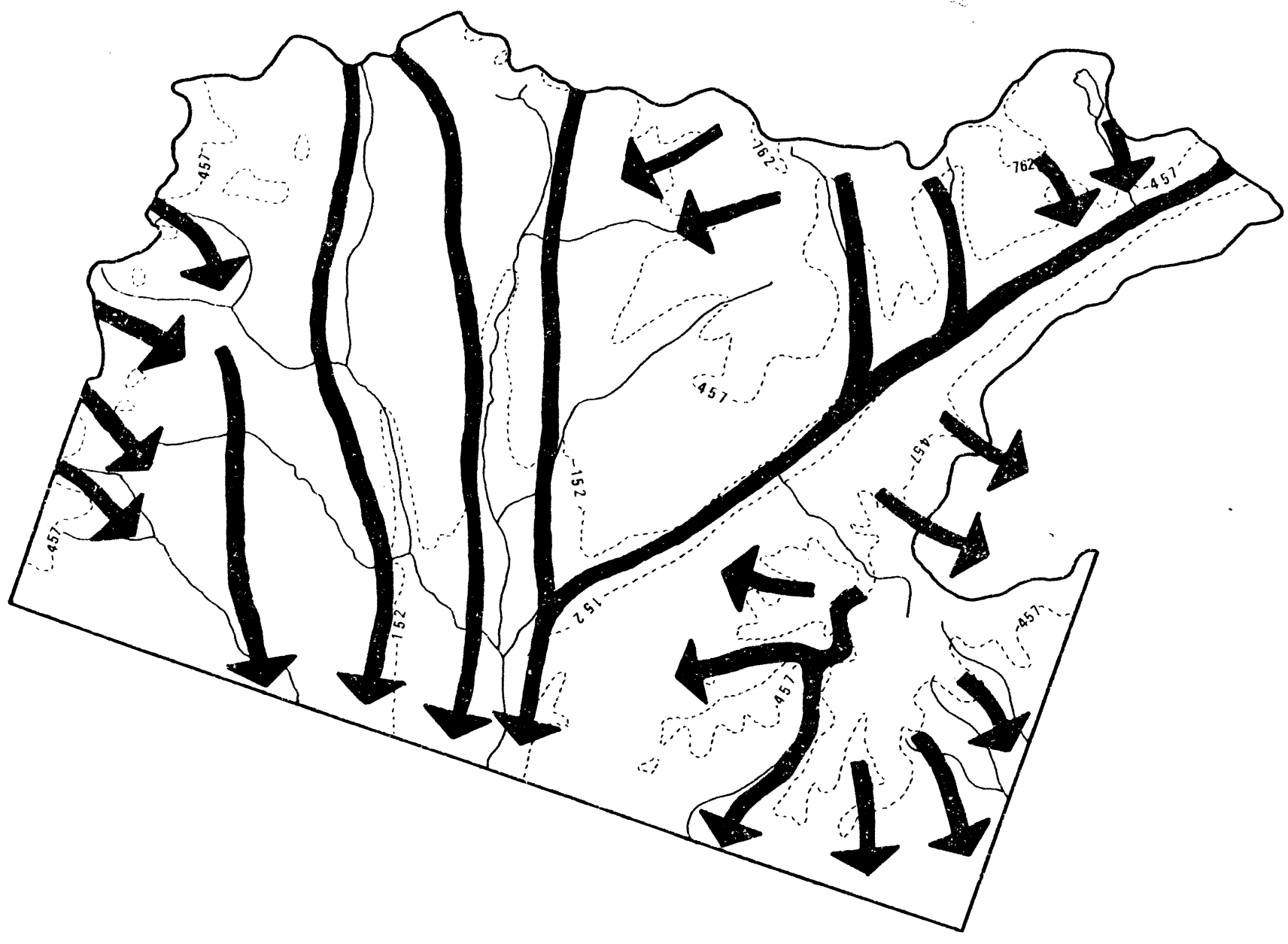
Orientation of the cirques by 10° sectors; peaks face N.E. and E.S.E.



The altitude of the lip of the basin was measured where possible. Where there was no obvious lip, the altitude refers to the break of slope at the foot of the headwall.

Fig. 3.10. Area I - Altitude and orientation of cirques.

Fig. 3.23. Principal directions of ice movement across Area 1 during the last Glaciation.



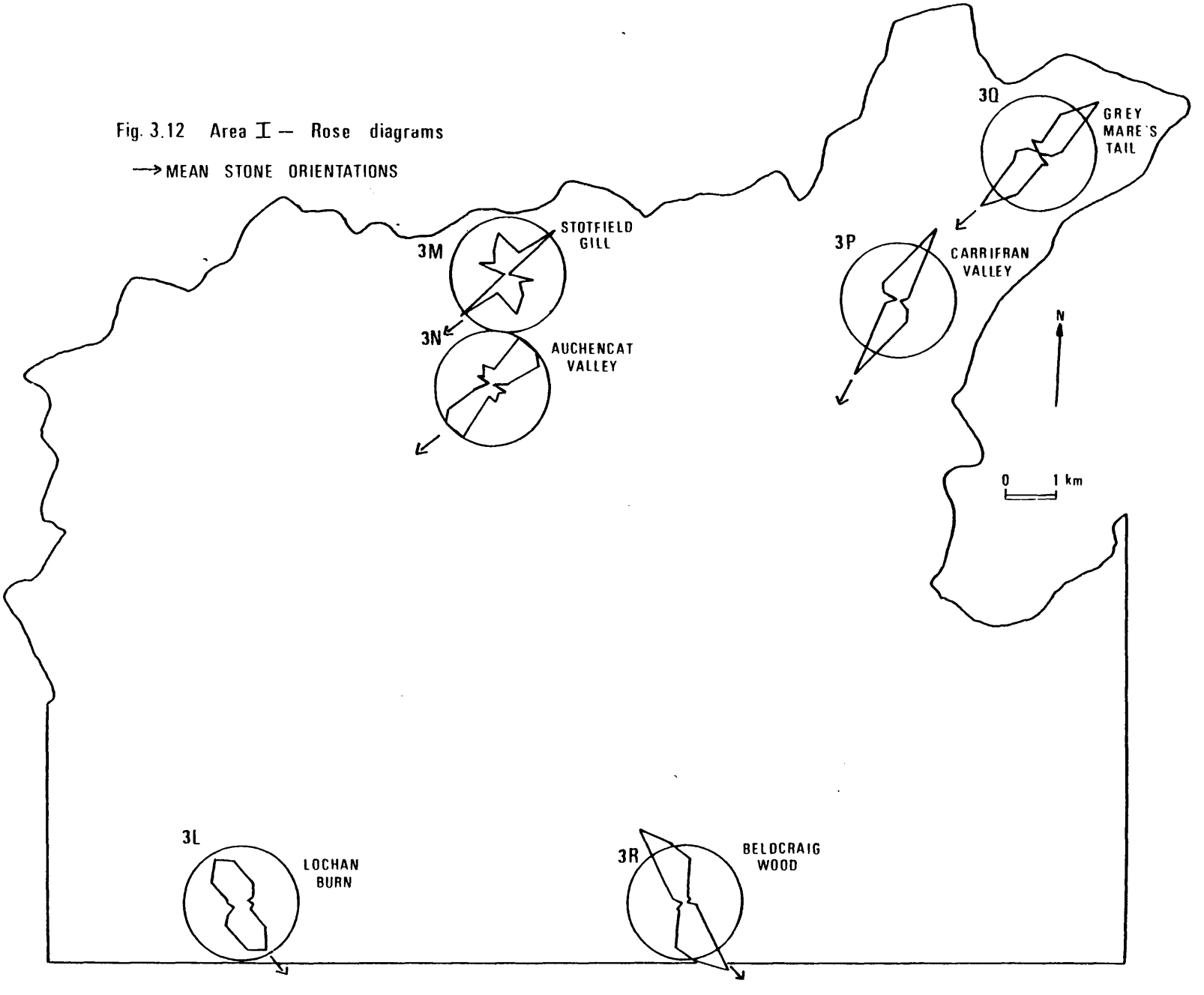


Fig. 3.12 Area I — Rose diagrams

→ MEAN STONE ORIENTATIONS

DRUMLIN	Altitude of Crest mod	Length (km)	Maximum Width (m)	Constituents T— Till B— Bedrock
A	107	1·1	250	T
B	107	1·0	300	T
C	190	2·1	260	T/B
D	210	1·5	430	T/B
E	197	1·3	350	B
F	228	1·7	560	B
G	237	1·4	390	B

Table 3.3

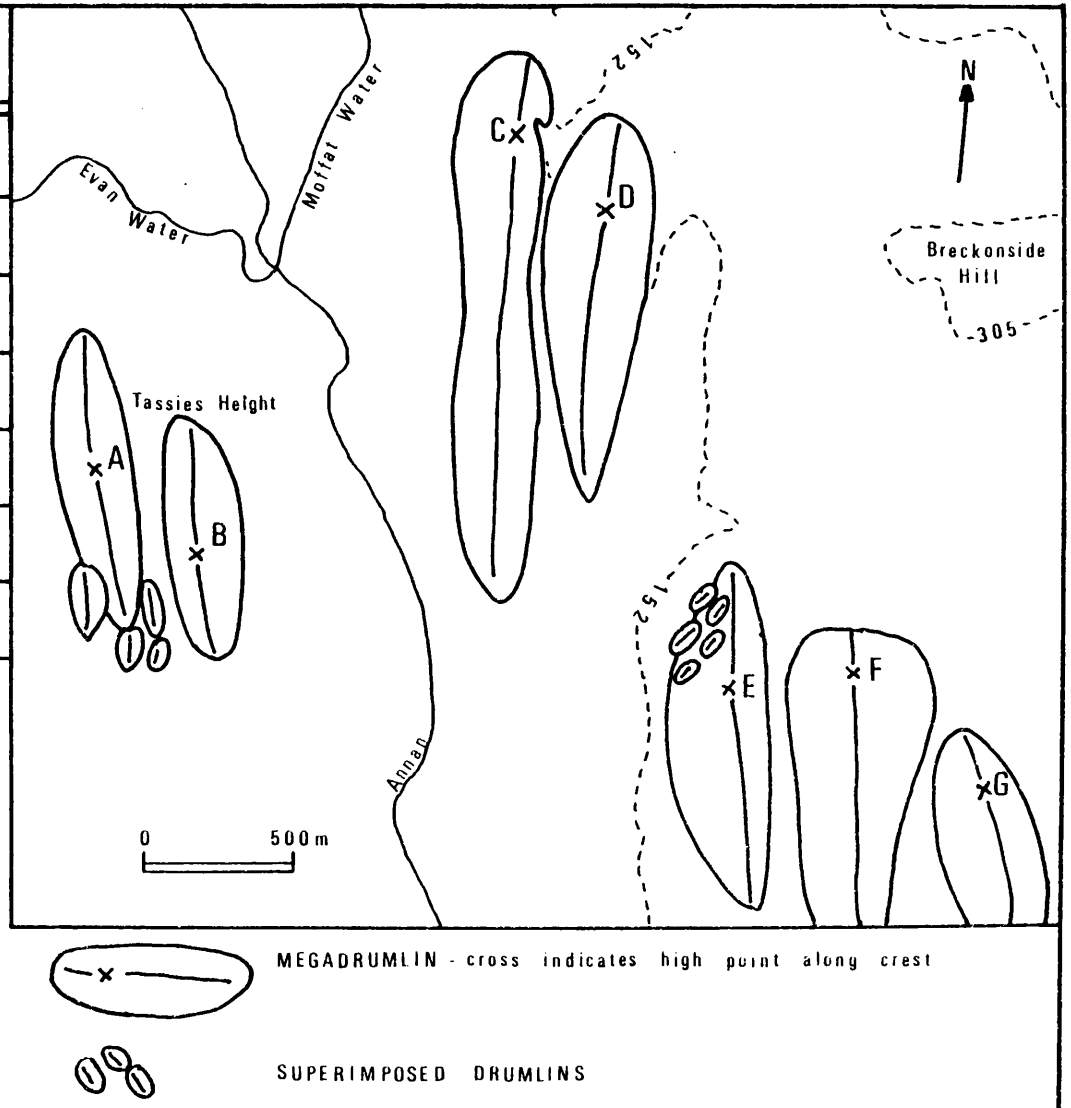


Fig. 3.13. Drumlinoid forms in Area I.

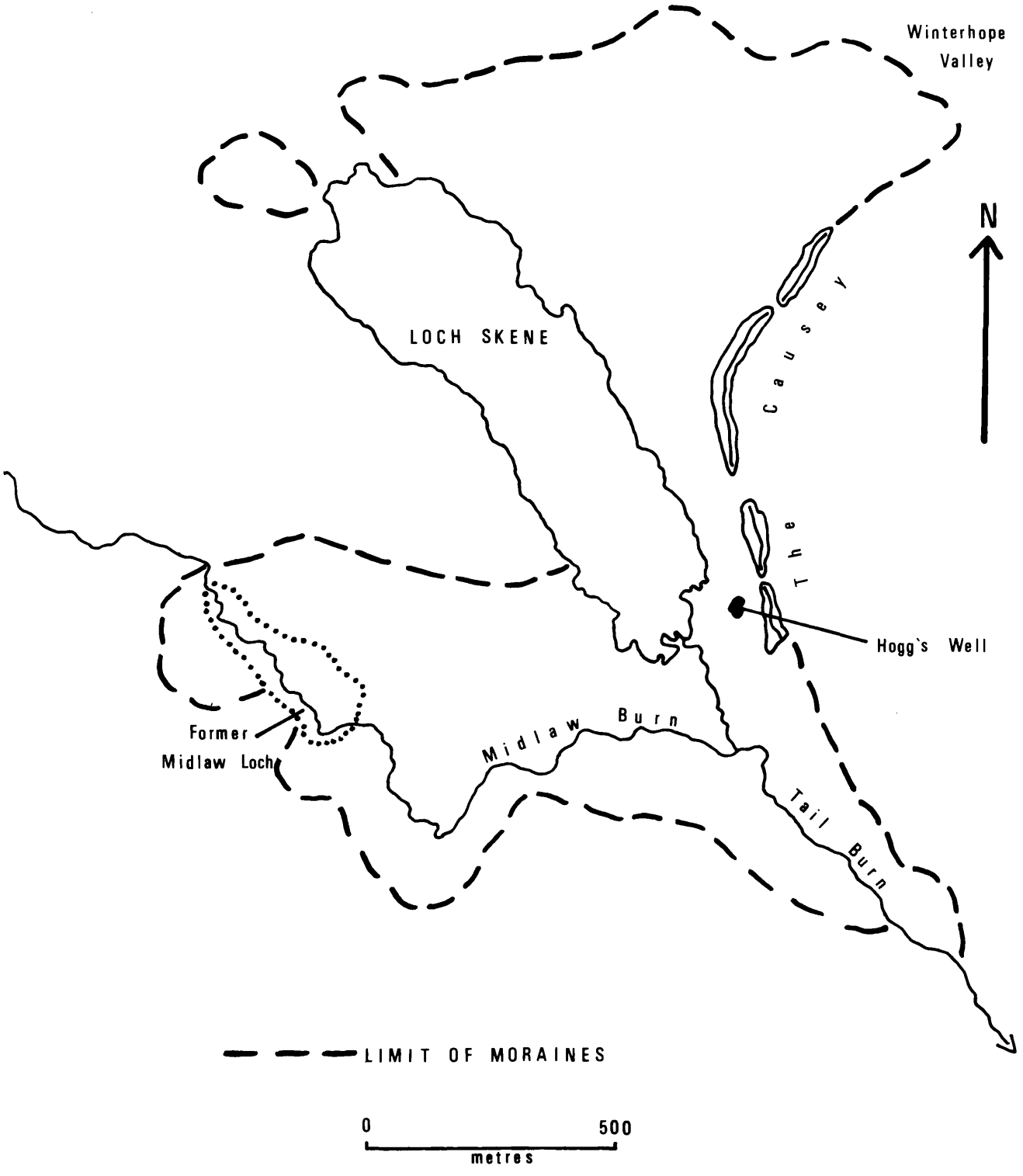


Fig. 3.14 Morainic landforms in the vicinity of Loch Skene

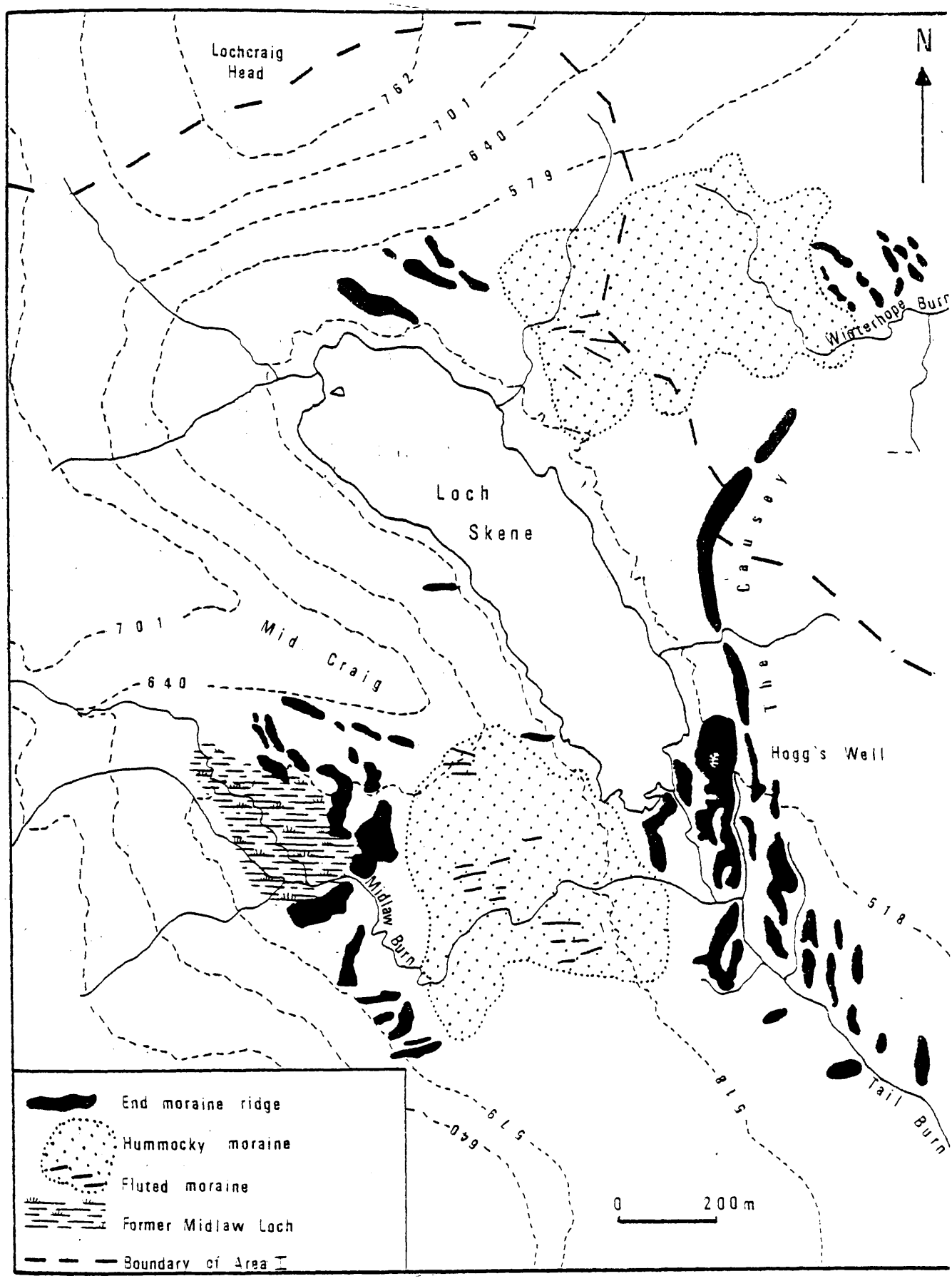


Fig. 3.15. Loch Skene moraines.

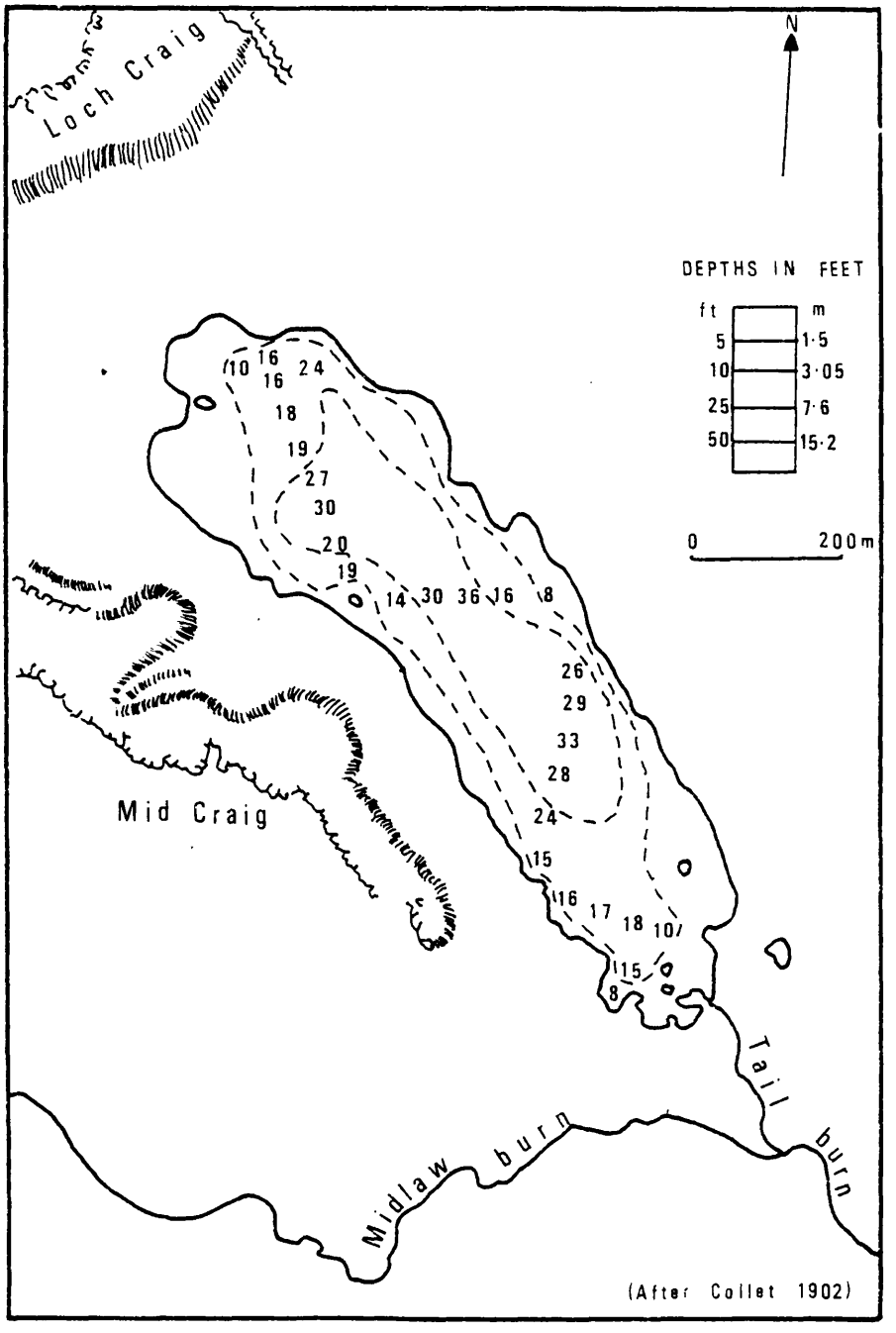


Fig. 3.16. Bathymetric survey of Loch Skene.

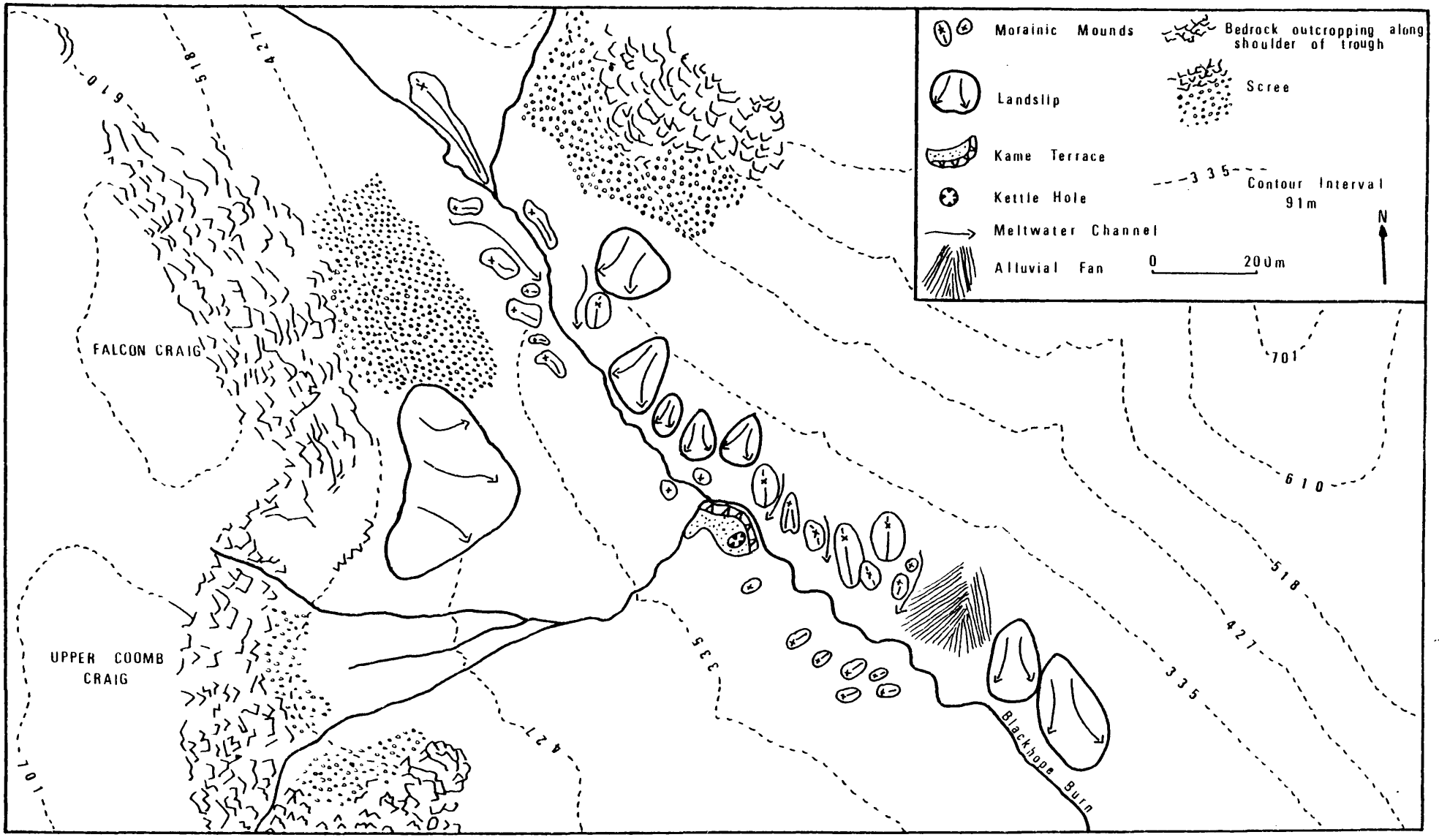
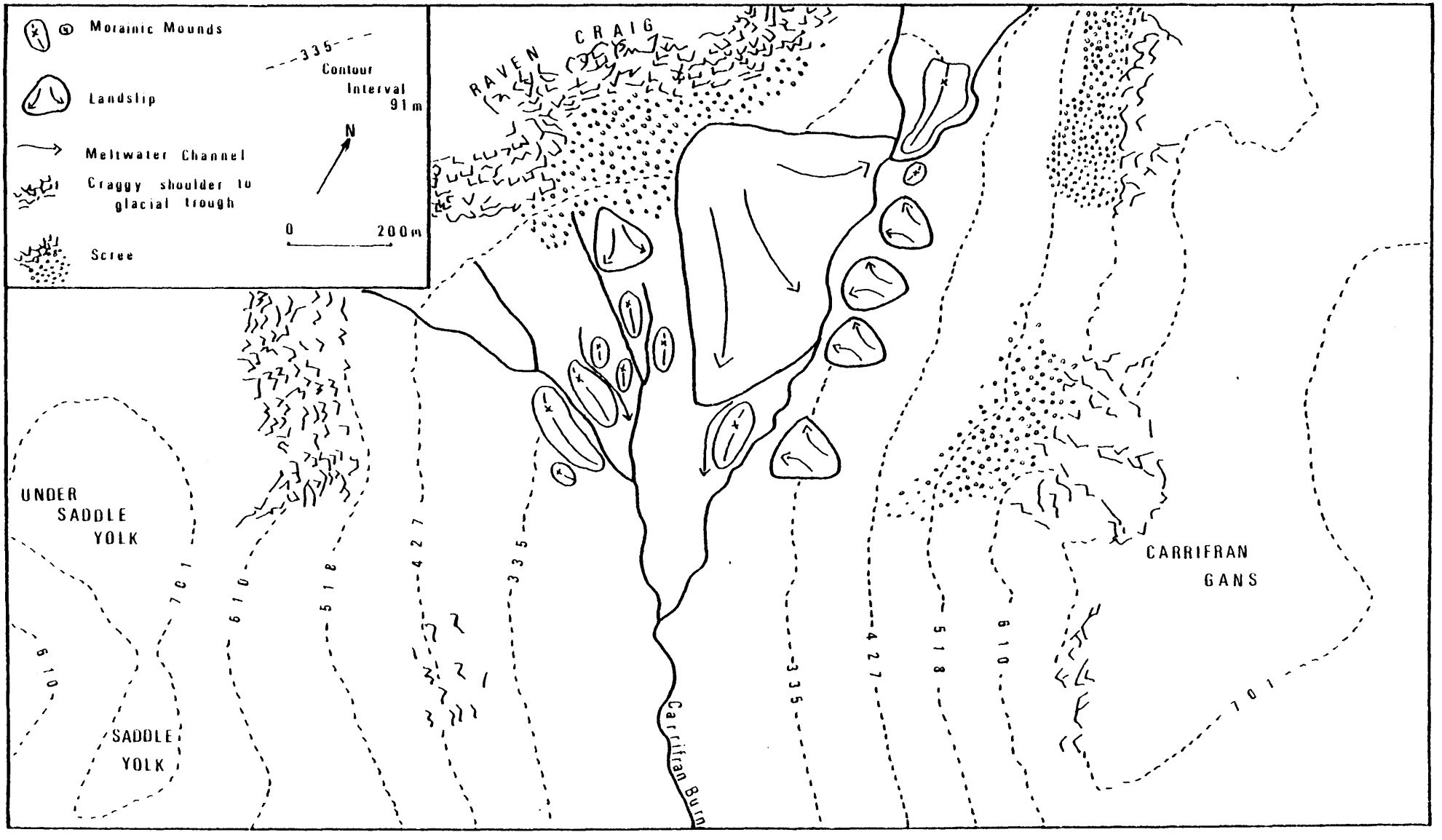


Fig. 3.17. Moraines in the Blackhope valley.


Moraimic Mounds
335
Contour Interval 91m
Landslip
N
Meltwater Channel
Craggy shoulder to glacial trough
0
200m
Scree
RAVEN CRAIG
UNDER SADDLE YOLK
SADDLE YOLK
CARRIFRAN GANS
Carrifran Burn
701
610
518
427
335

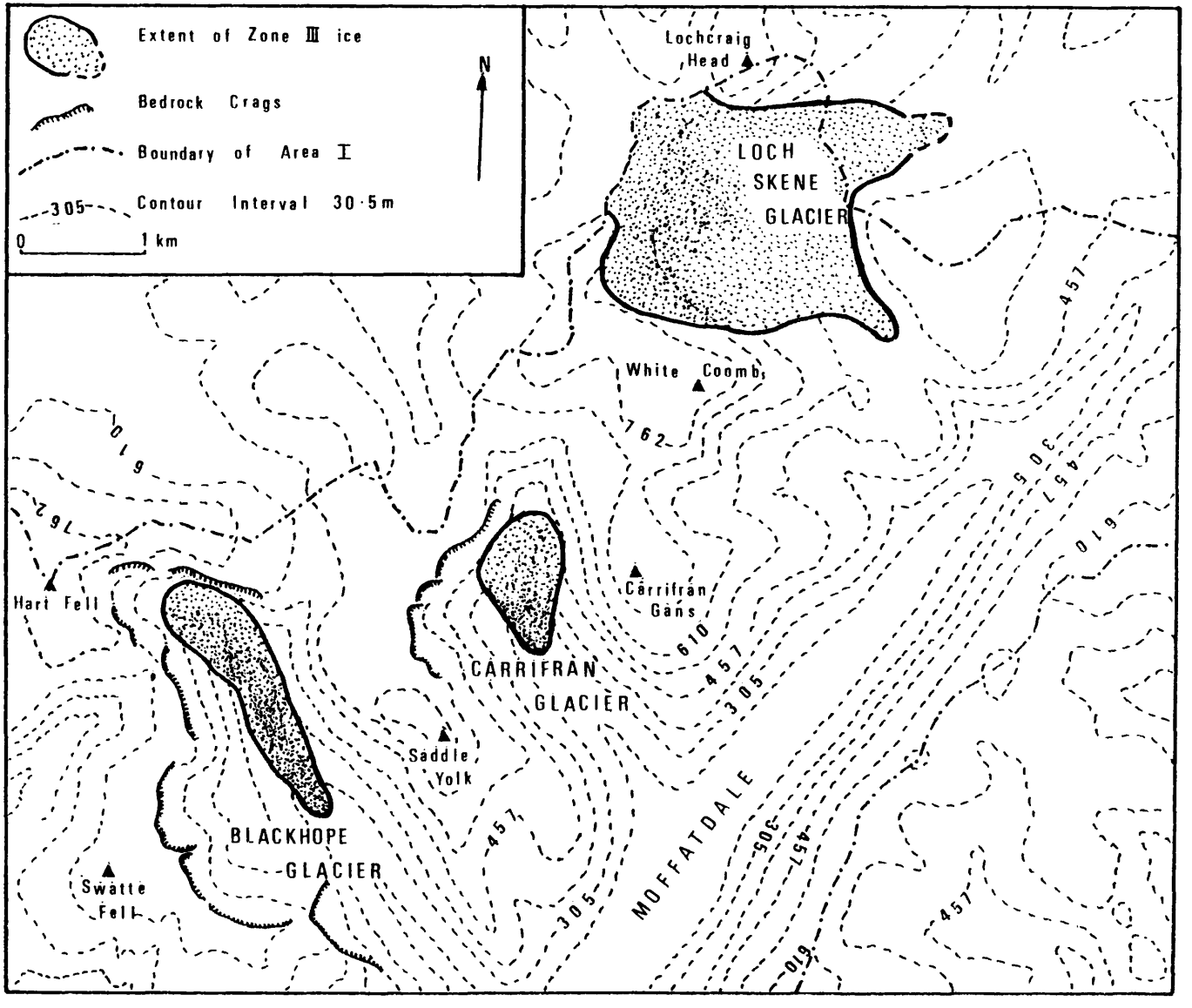
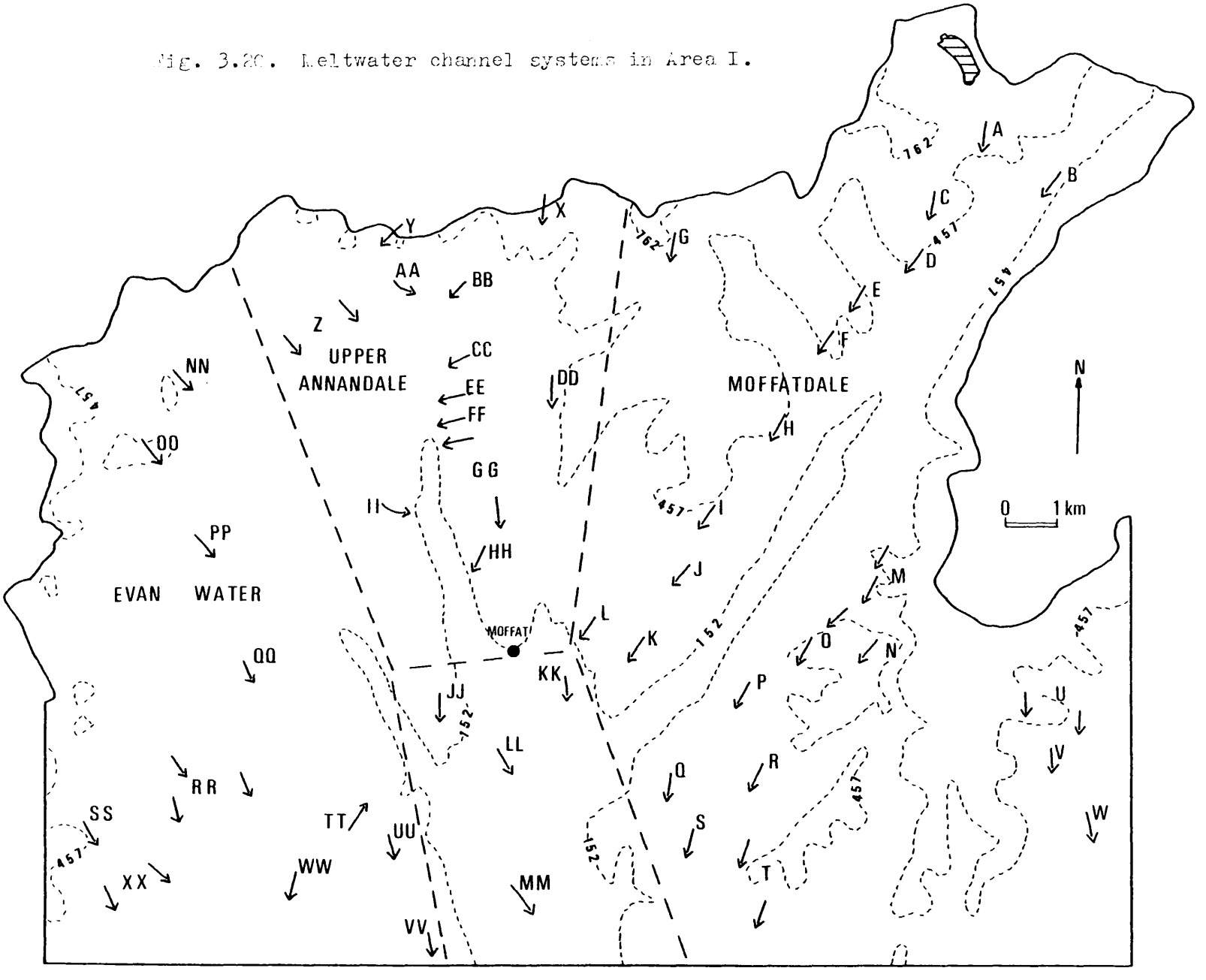


Fig. 3.19. Extent of Zone III glaciers in Area I.

Fig. 3.20. Meltwater channel systems in Area I.



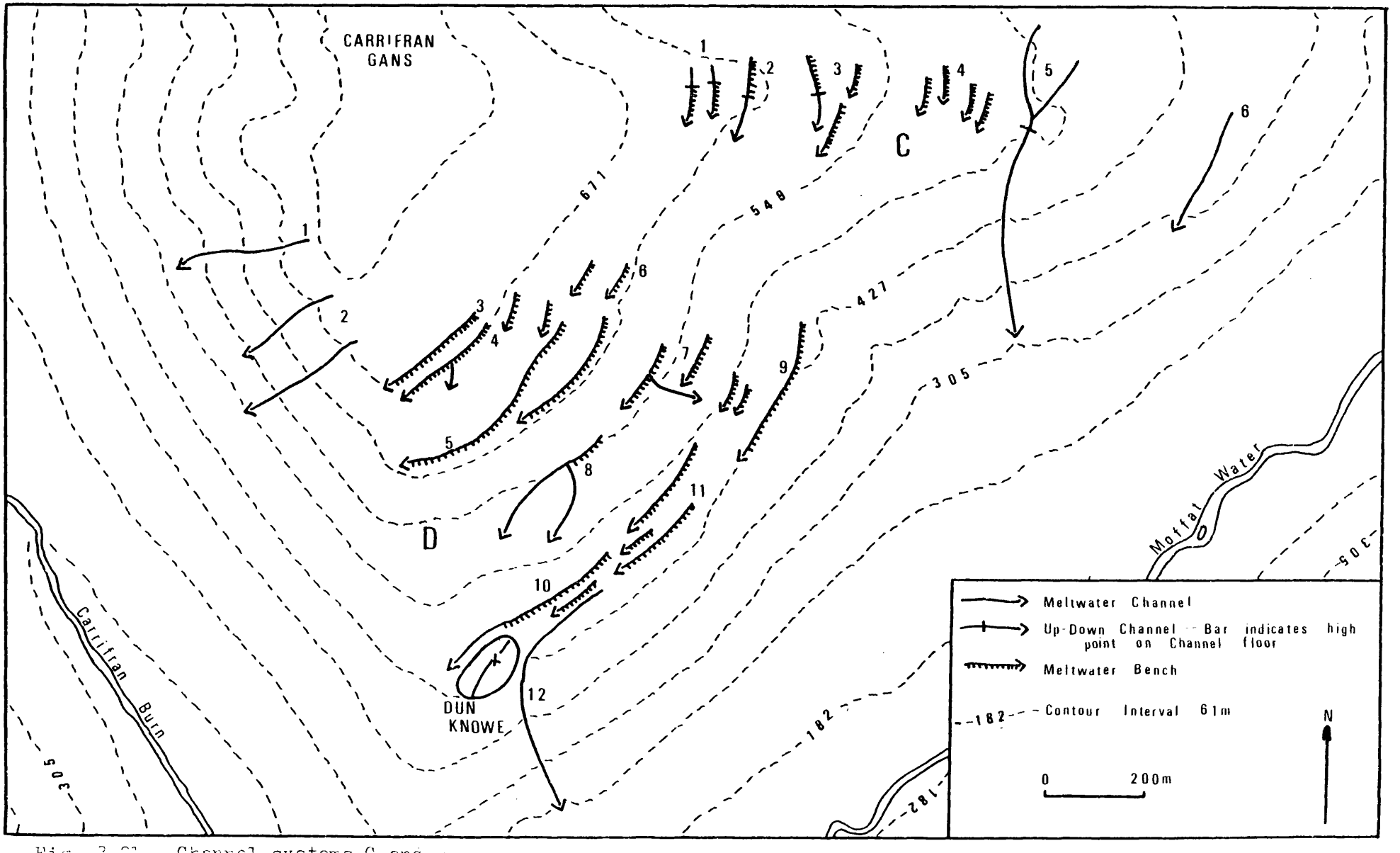
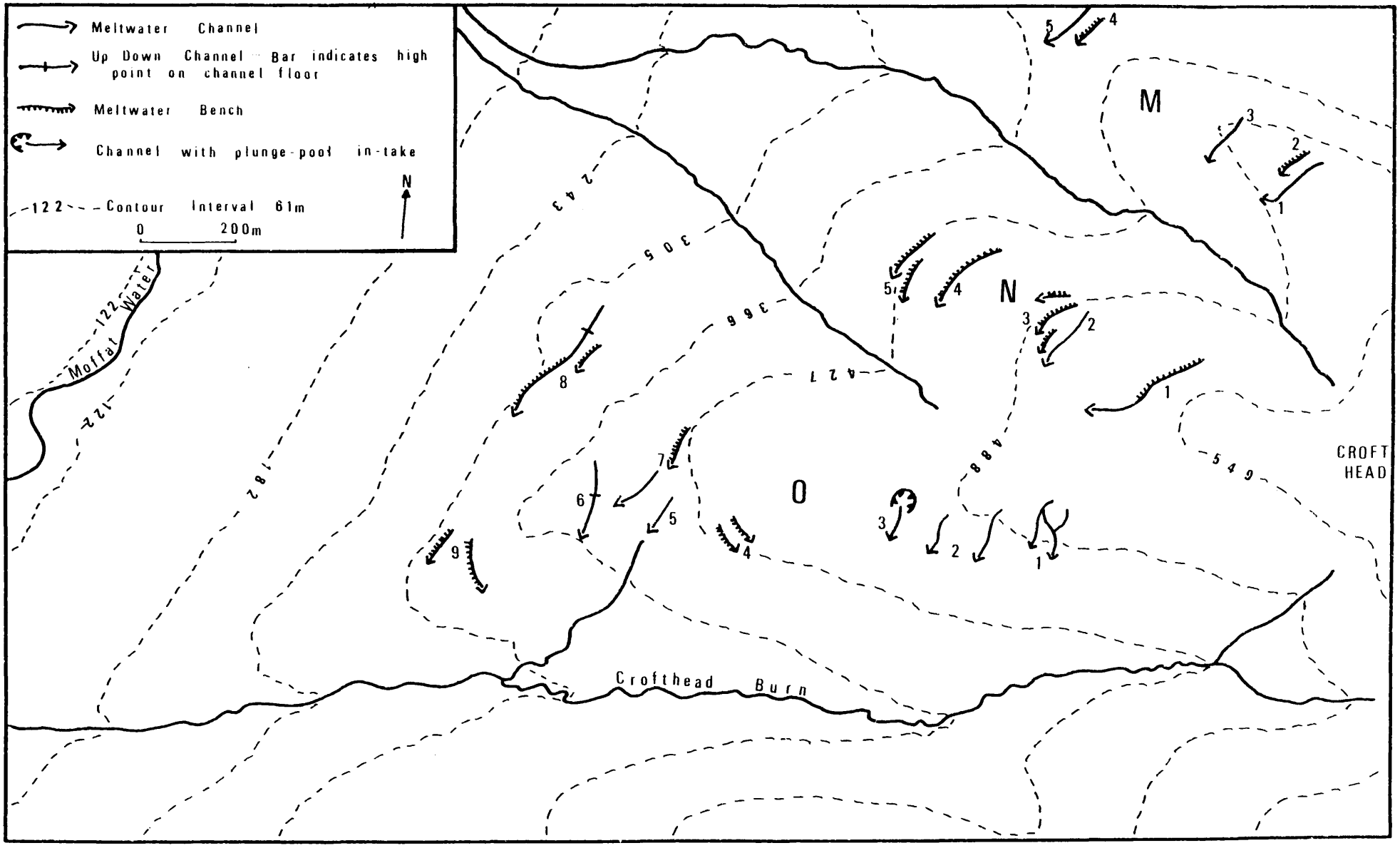


Fig. 3.21. Channel systems C and D.


Meltwater Channel
Up Down Channel Bar indicates high point on channel floor
Meltwater Bench
Channel with plunge-pool in-take
122 Contour Interval 61m
0 200m
N
Moffat Water
Crofthead Burn
CROFT HEAD
M
N
O
122
182
243
305
366
427
488
549

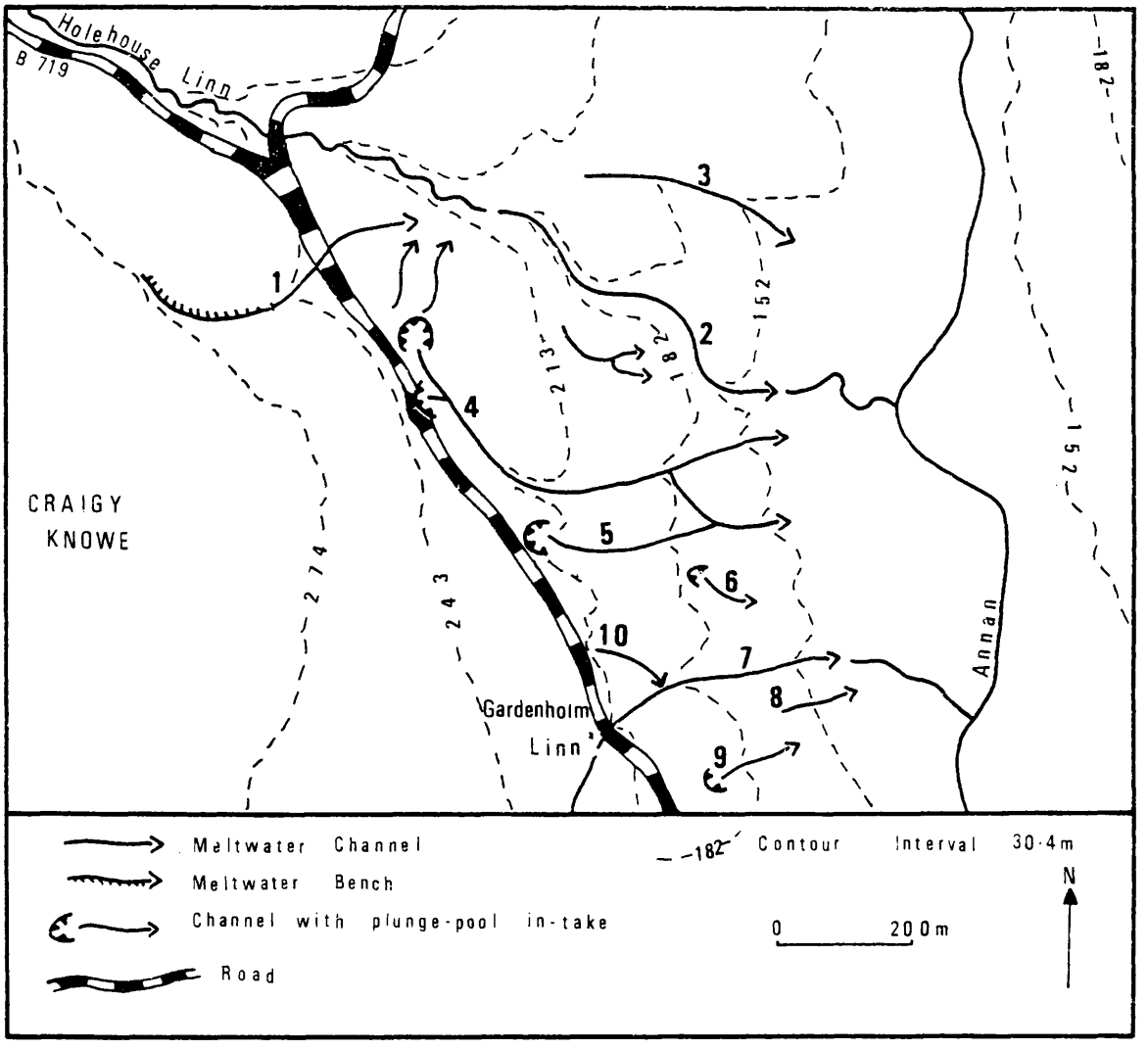


Fig. 3.23. Channel system II.

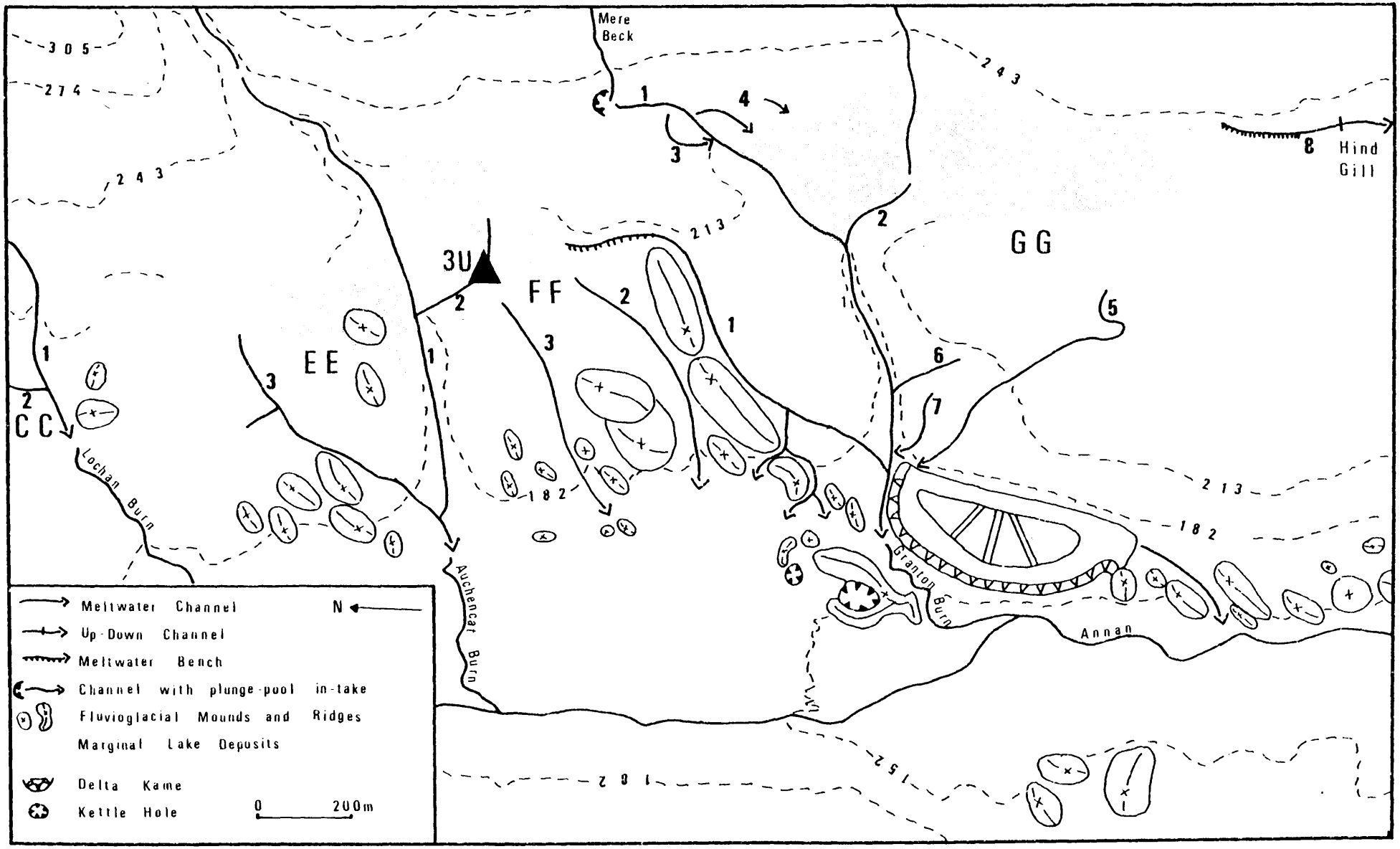


Fig. 3.24. Channel systems CC, EE, FF and GG.

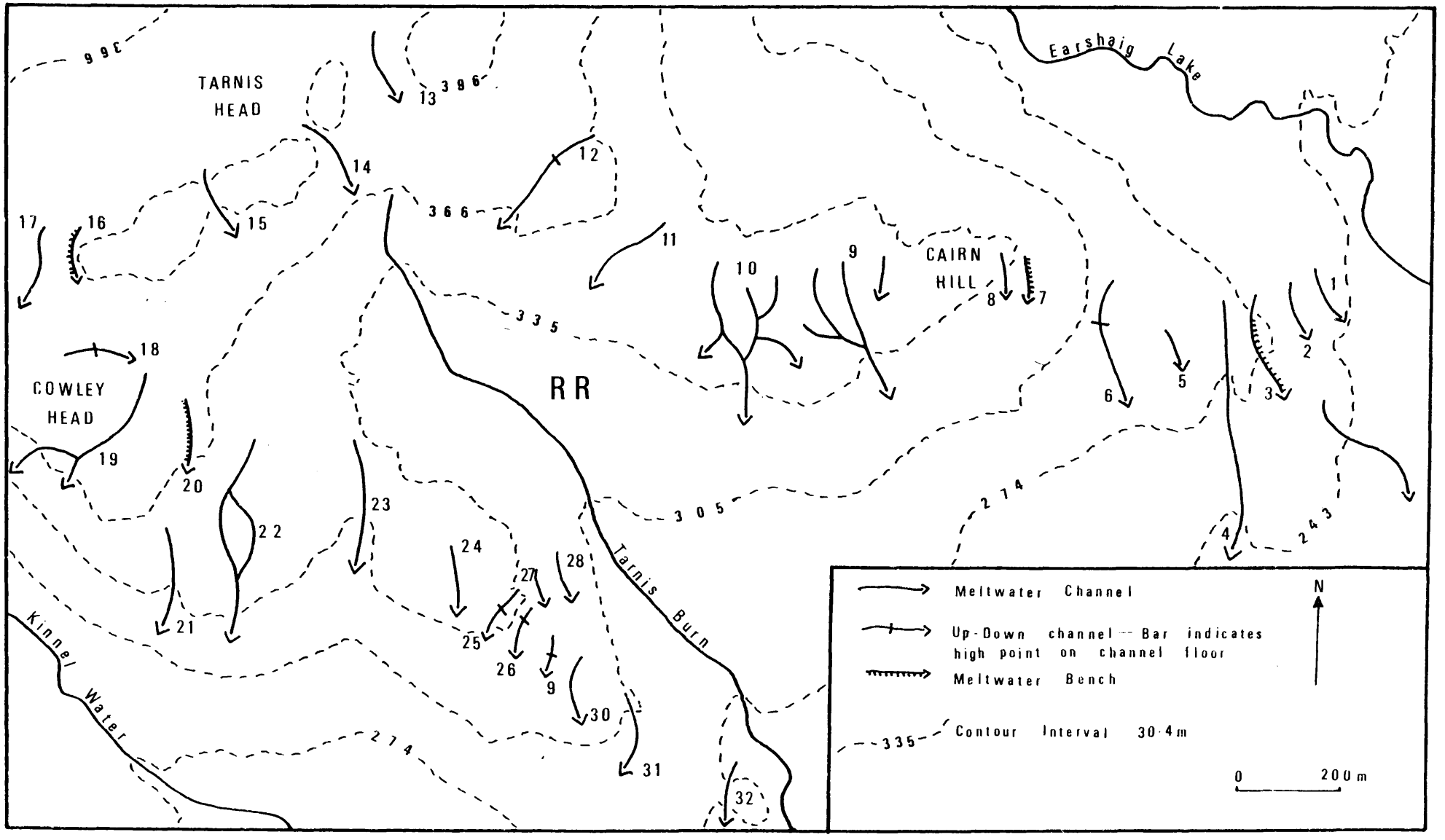


Fig. 3.25. Channel system RR.

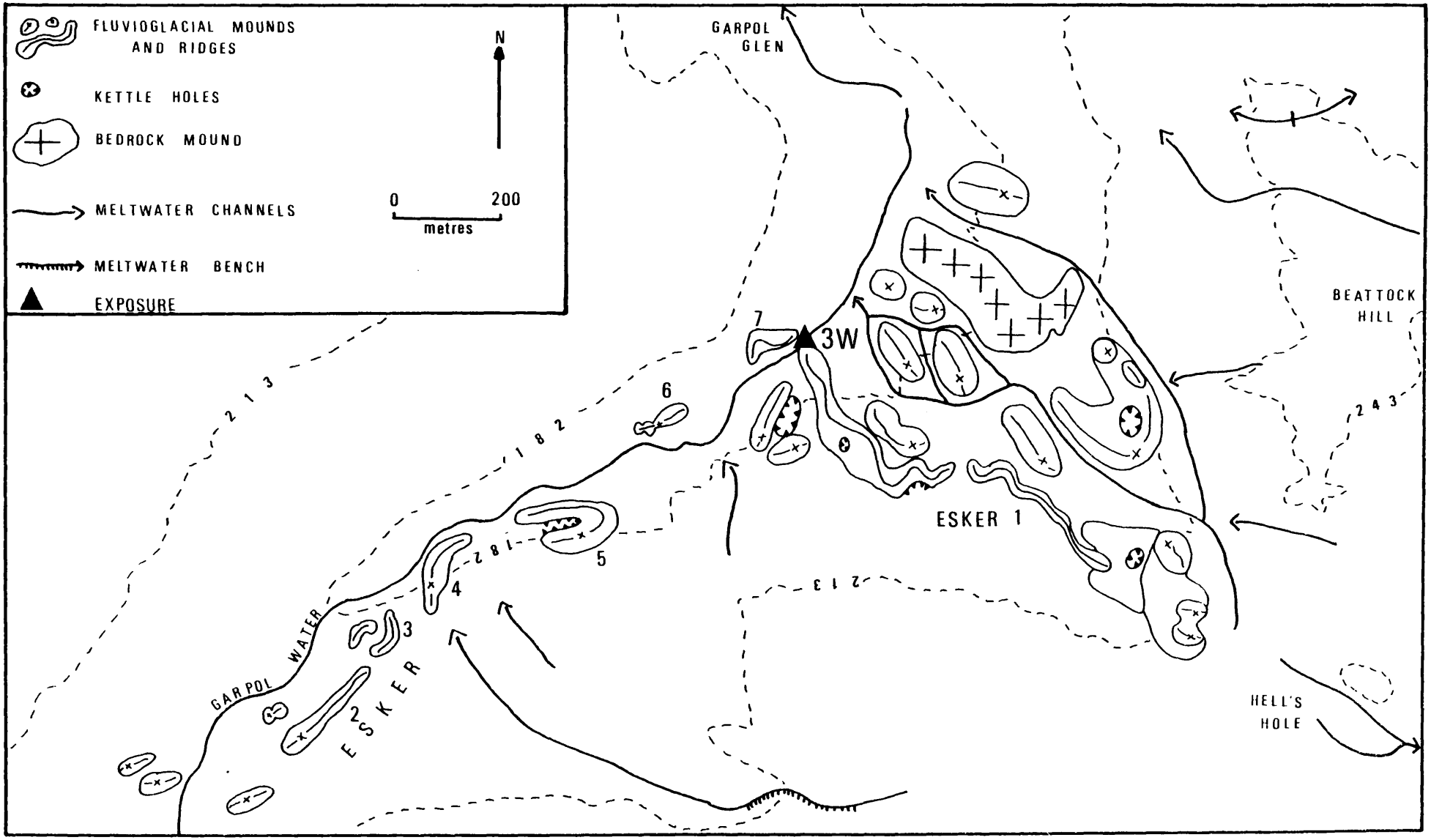


Fig. 3.26. Fluvioglacial landforms in the Garpol Water Valley.

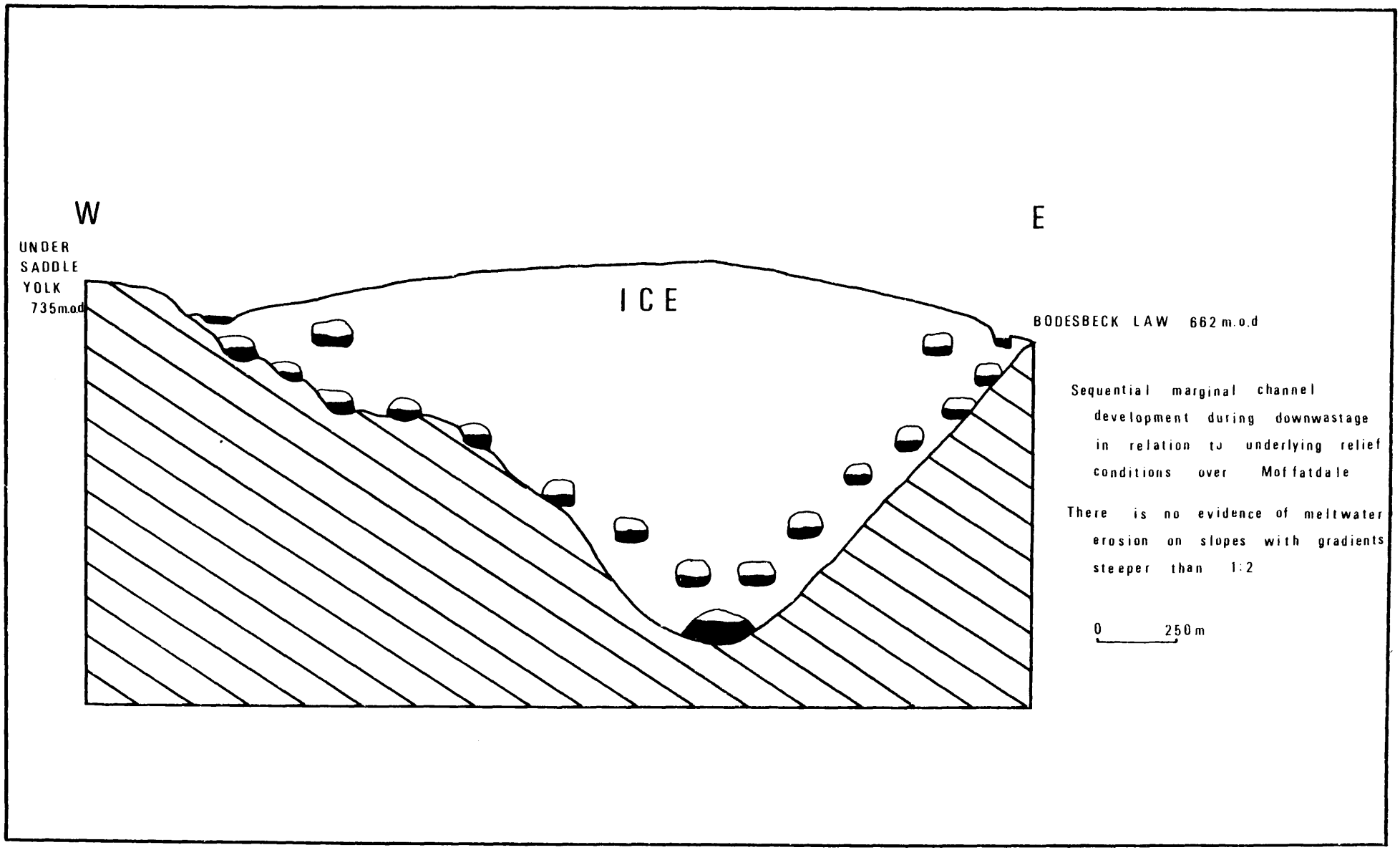


Fig. 3.27. Channel development in relation to relief conditions in Moffatdale.

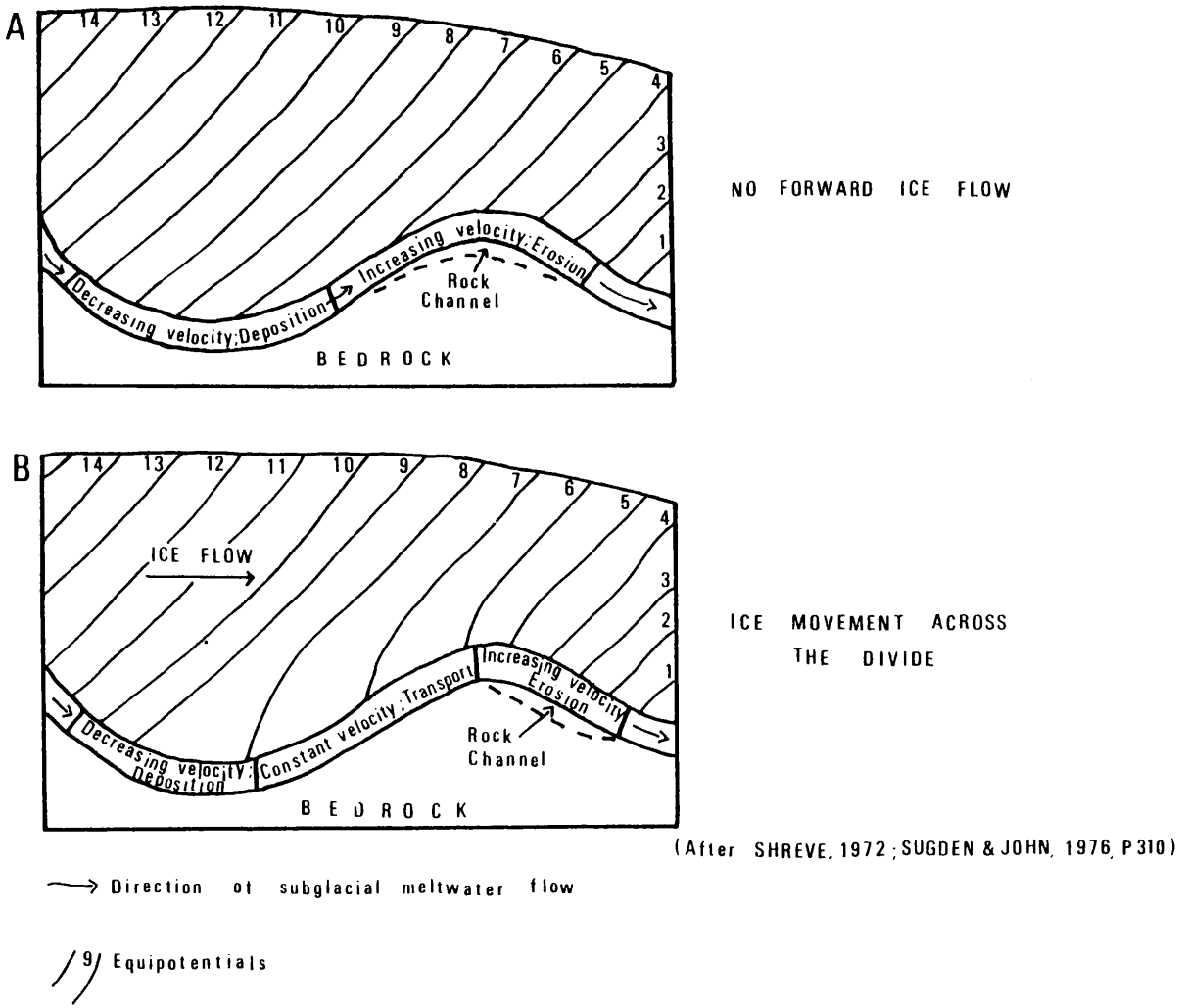
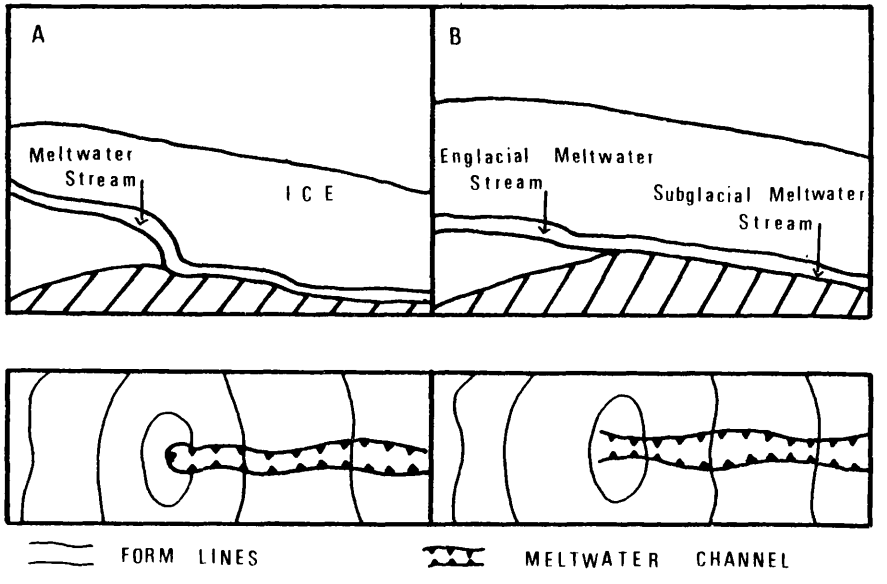
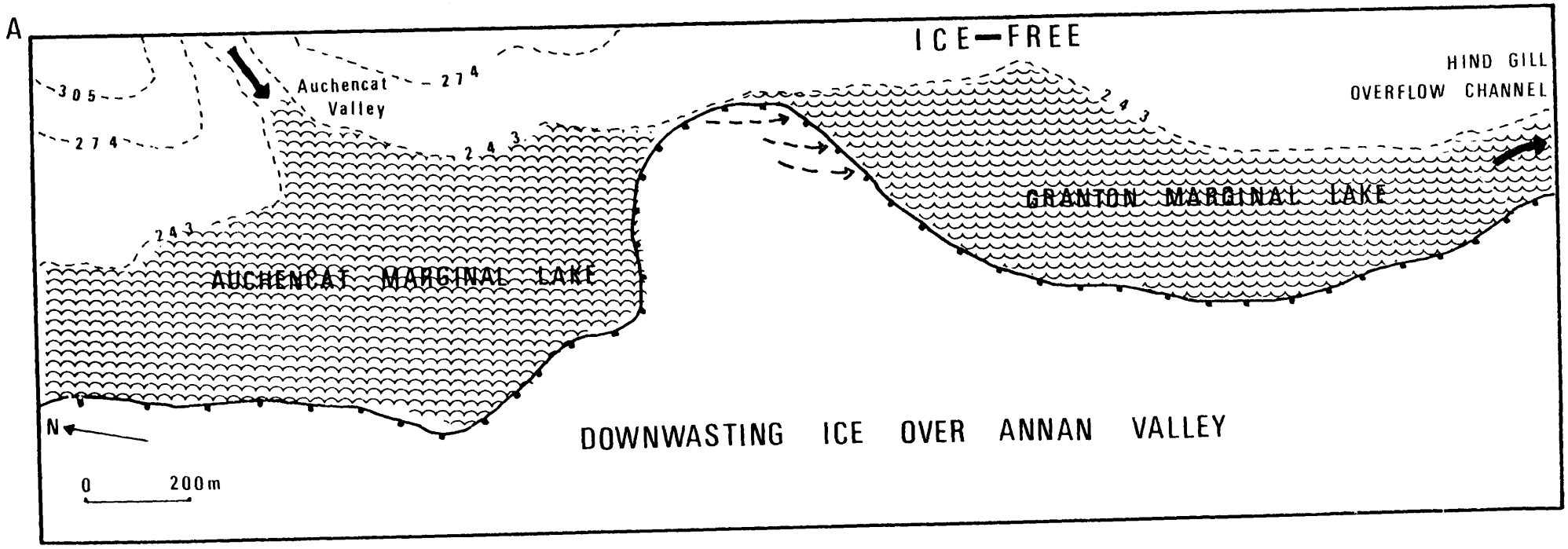


Fig. 3.28. The erosion of ice-directed rock channels across a divide.



(PRICE, 1973, P119)

Fig. 3.29. Superimposition of englacial streams.



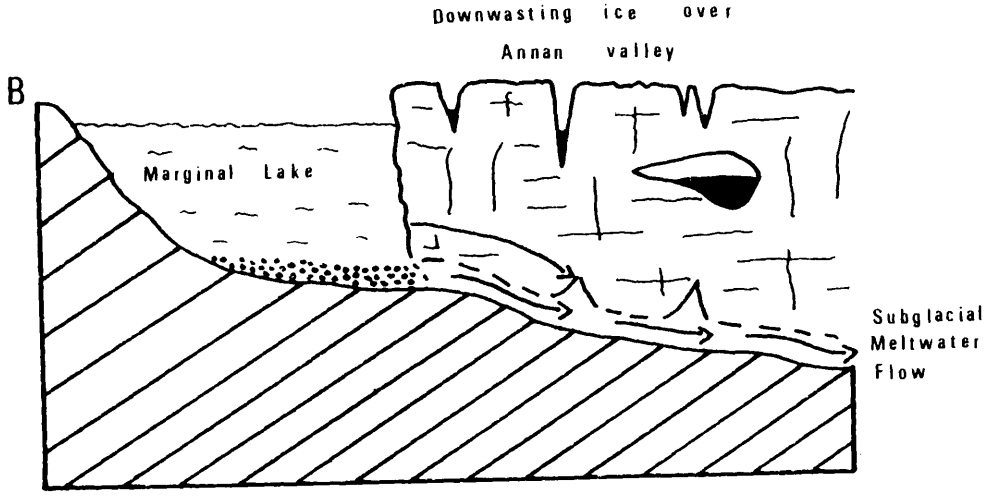


Fig. 3.7 . [illegible] drainage of Auchencat and Granton marginal lakes, eastern Annandale.

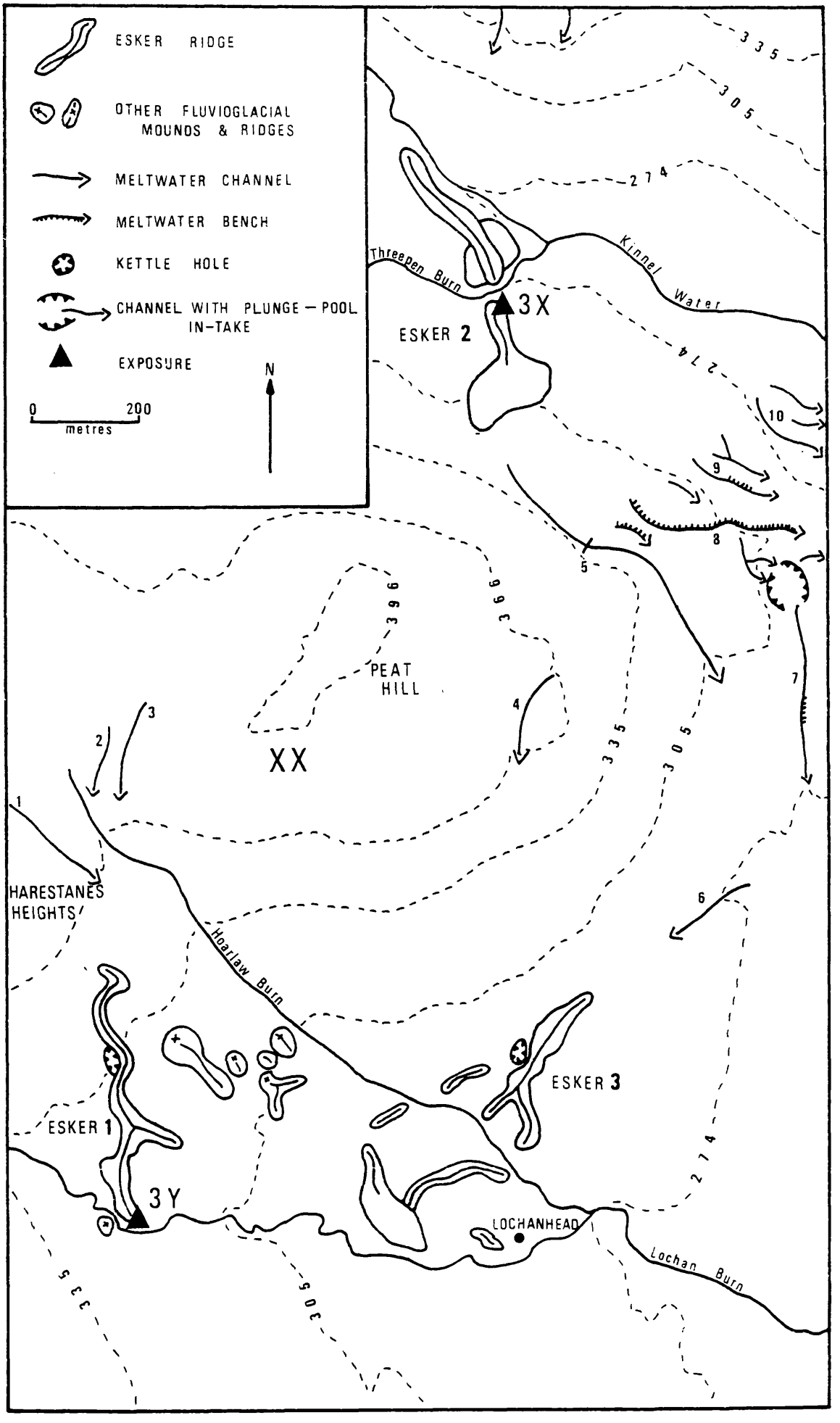


Fig. 3.31. Channel system XX and associated landforms.

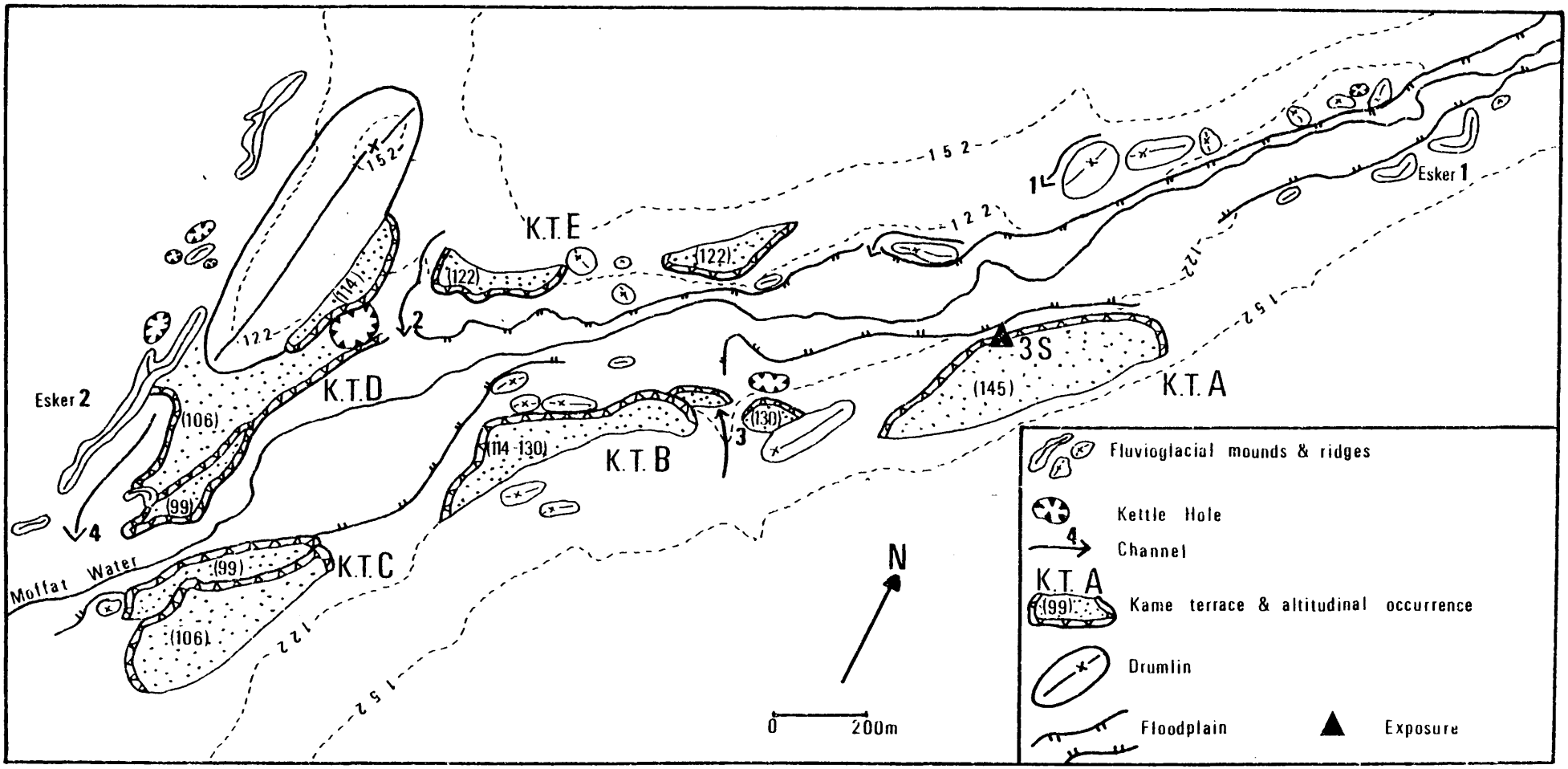
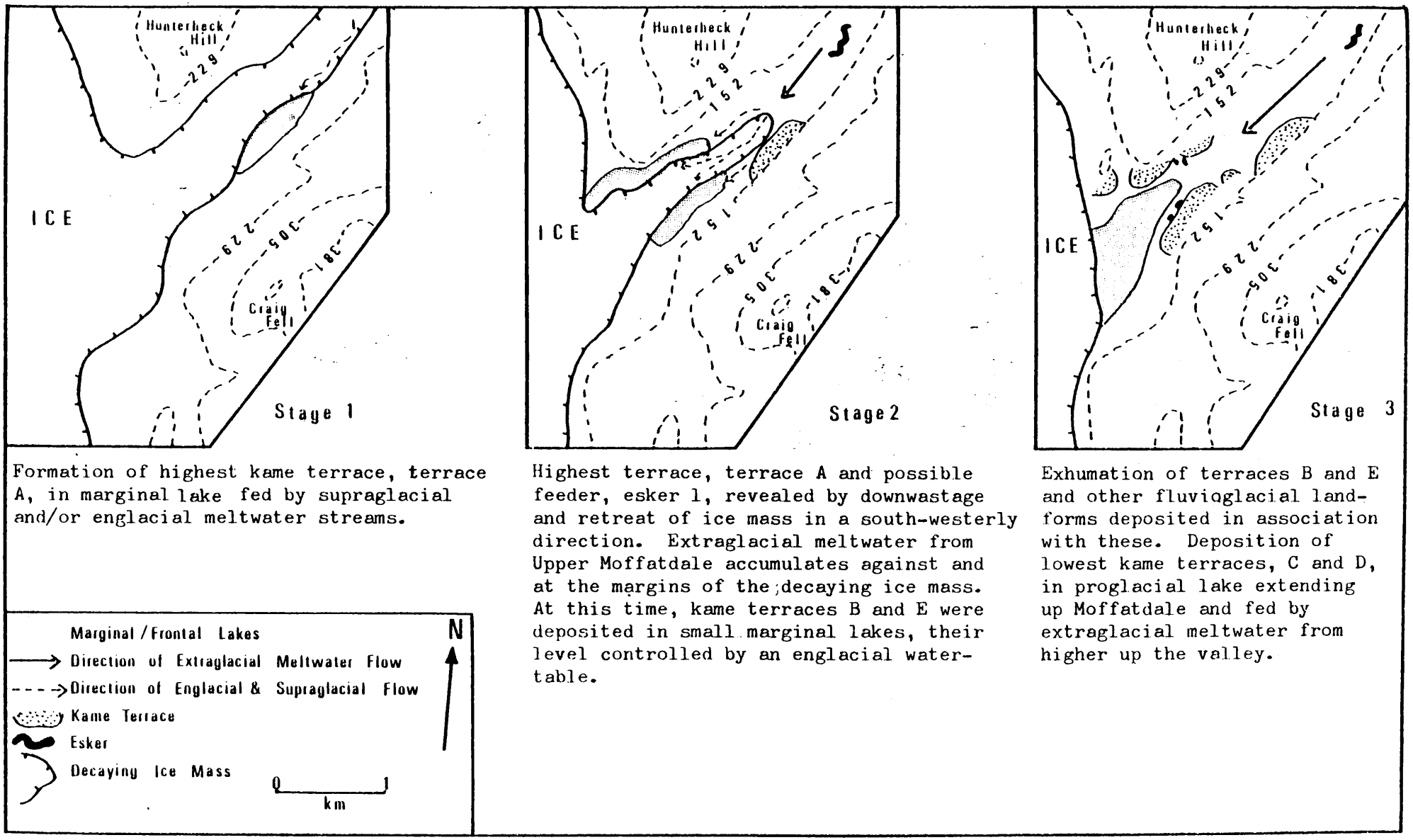


Fig. 3.32. Kame terraces in Lower Moffatdale.



Formation of highest kame terrace, terrace A, in marginal lake fed by supraglacial and/or englacial meltwater streams.

Highest terrace, terrace A and possible feeder, esker 1, revealed by downwastage and retreat of ice mass in a south-westerly direction. Extraglacial meltwater from Upper Moffatdale accumulates against and at the margins of the decaying ice mass. At this time, kame terraces B and E were deposited in small marginal lakes, their level controlled by an englacial water-table.

Exhumation of terraces B and E and other fluvioglacial landforms deposited in association with these. Deposition of lowest kame terraces, C and D, in proglacial lake extending up Moffatdale and fed by extraglacial meltwater from higher up the valley.

Fig. 3.33. Stages in the formation of kame terraces in Lower Moffatdale.

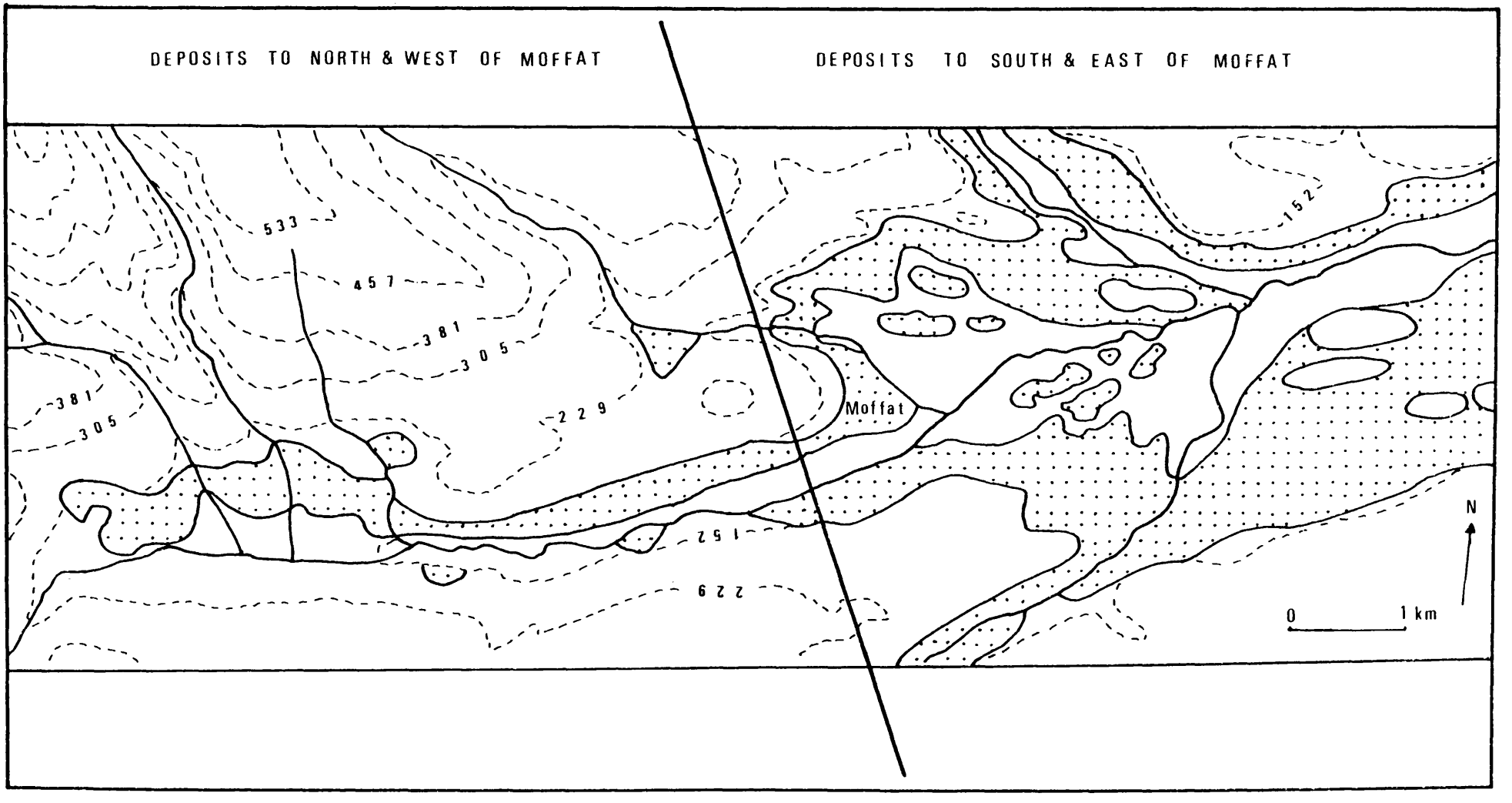


Fig. 3.34. Fluvioglacial deposits in Upper Annandale.

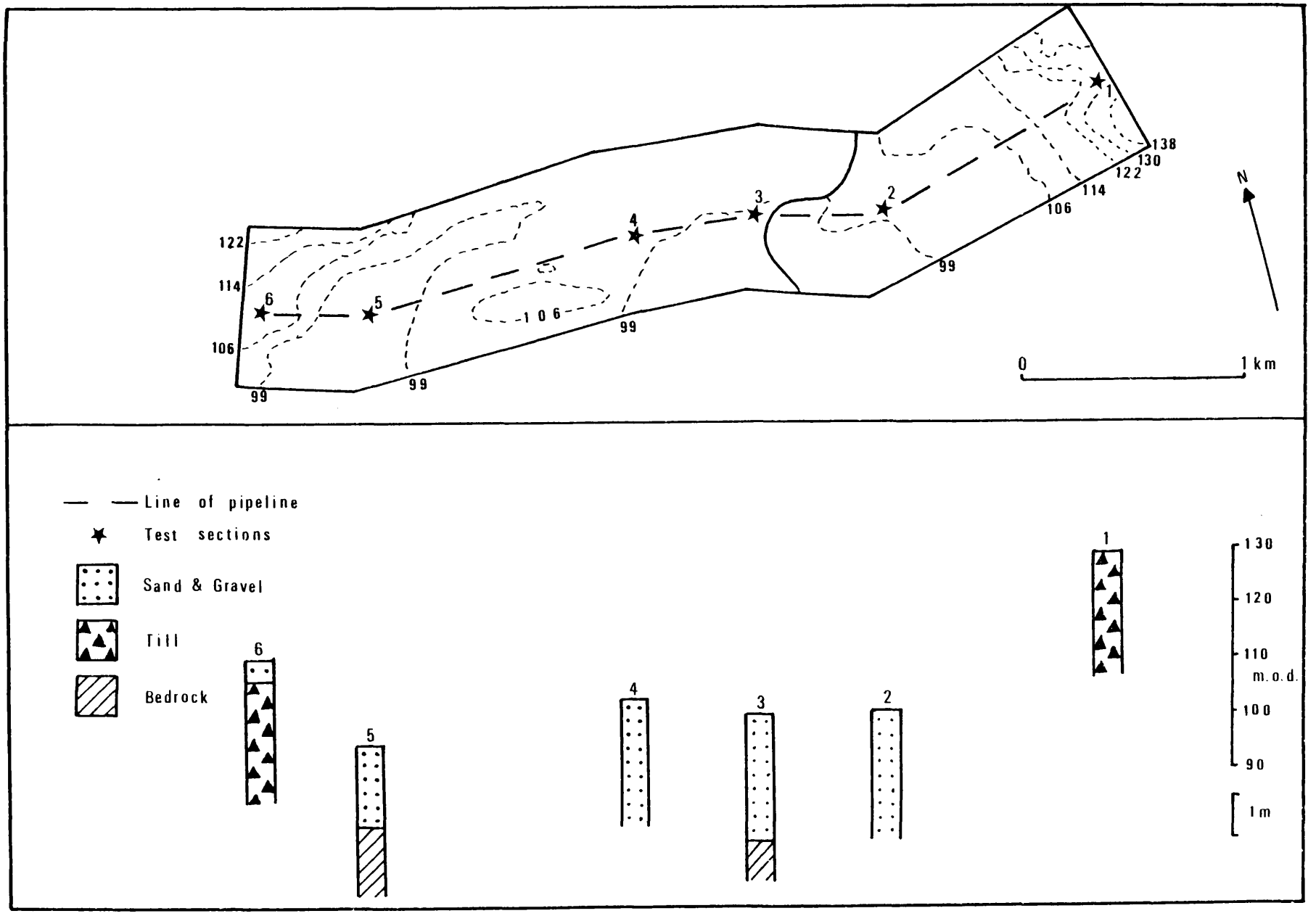


Fig. 3.35. Fluvioglacial deposits revealed by pipeline cuttings.

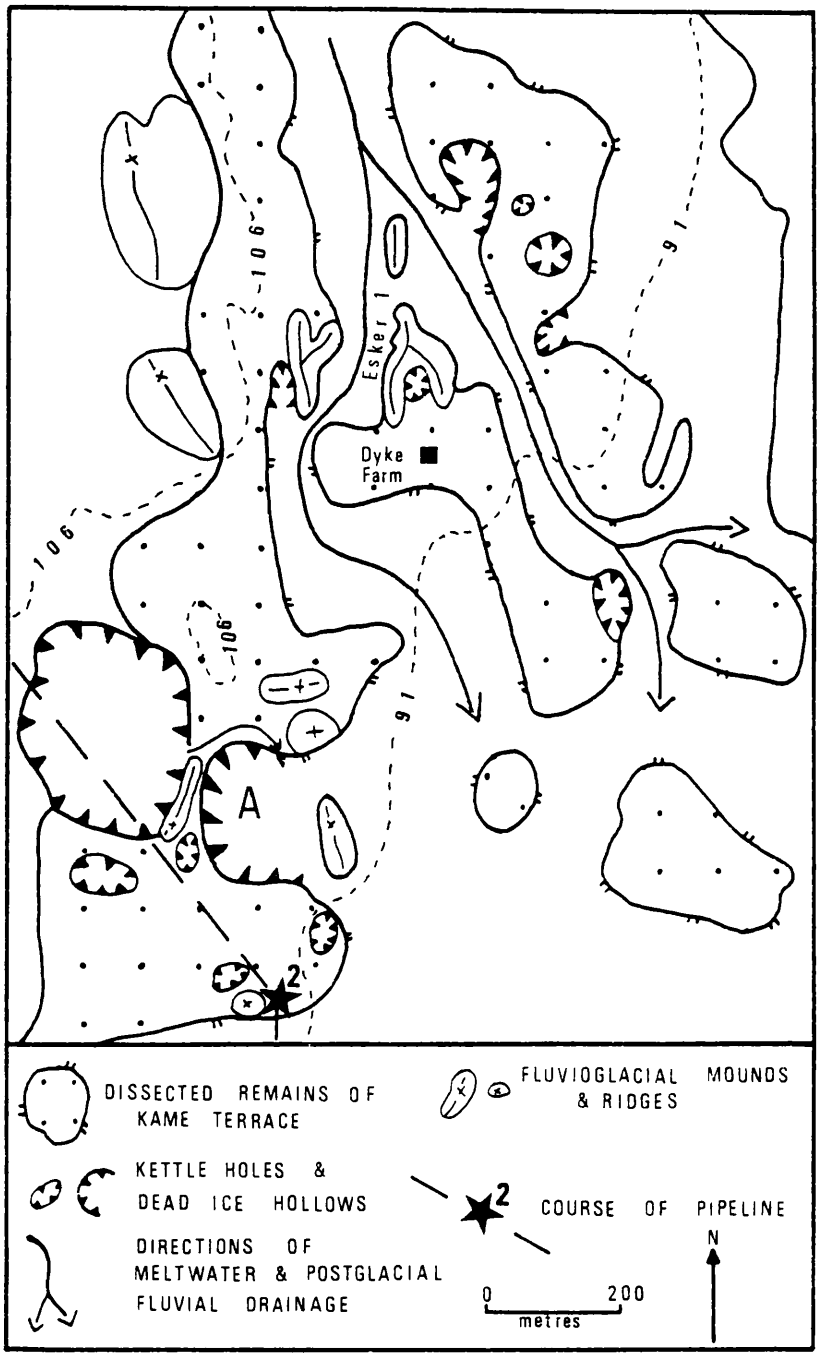


Fig. 3.36. Fluvioglacial landforms in the vicinity of Dyke Farm.

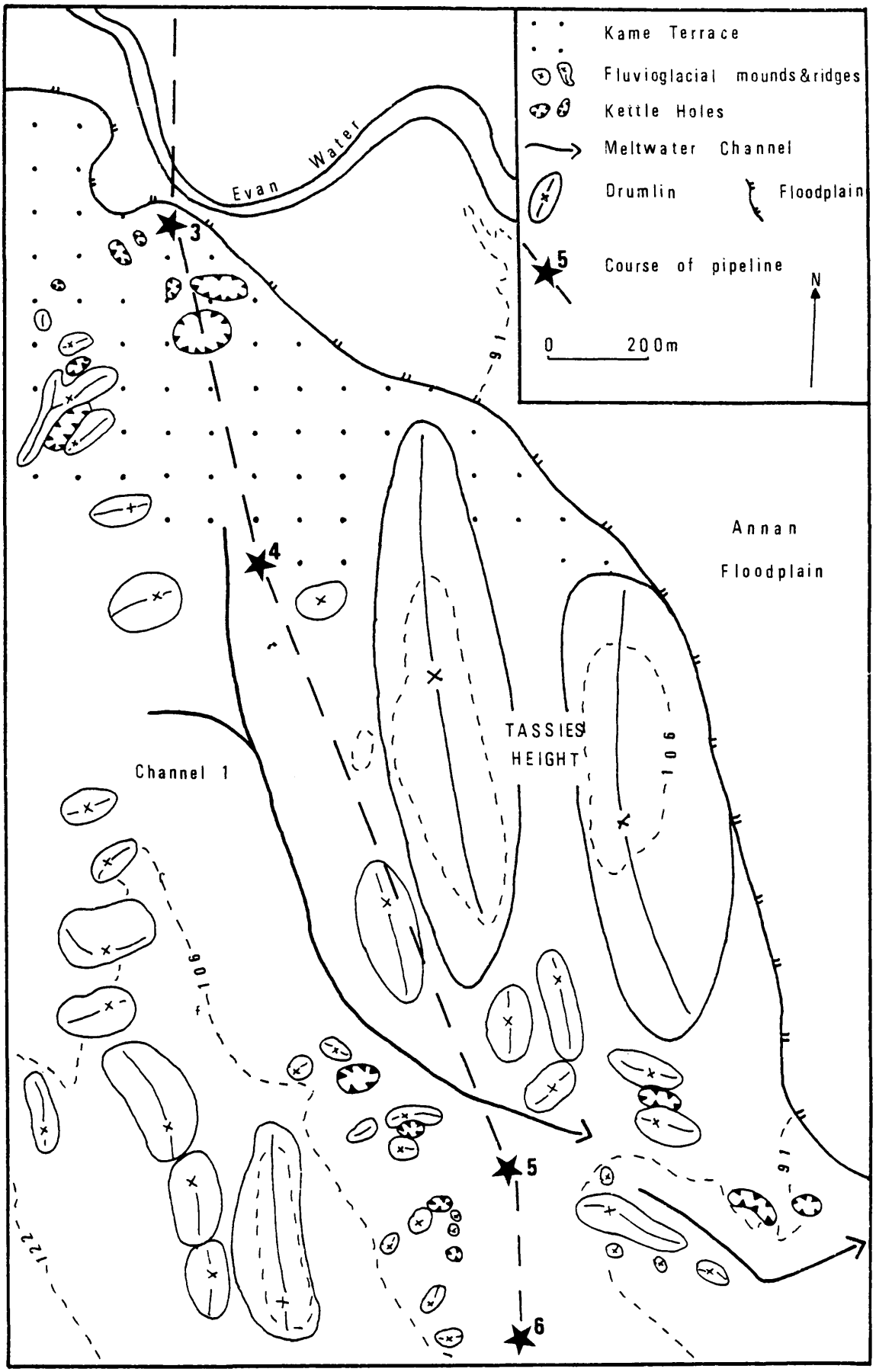


Fig. 3.37. Fluvioglacial landforms in the vicinity of Tassies Height.

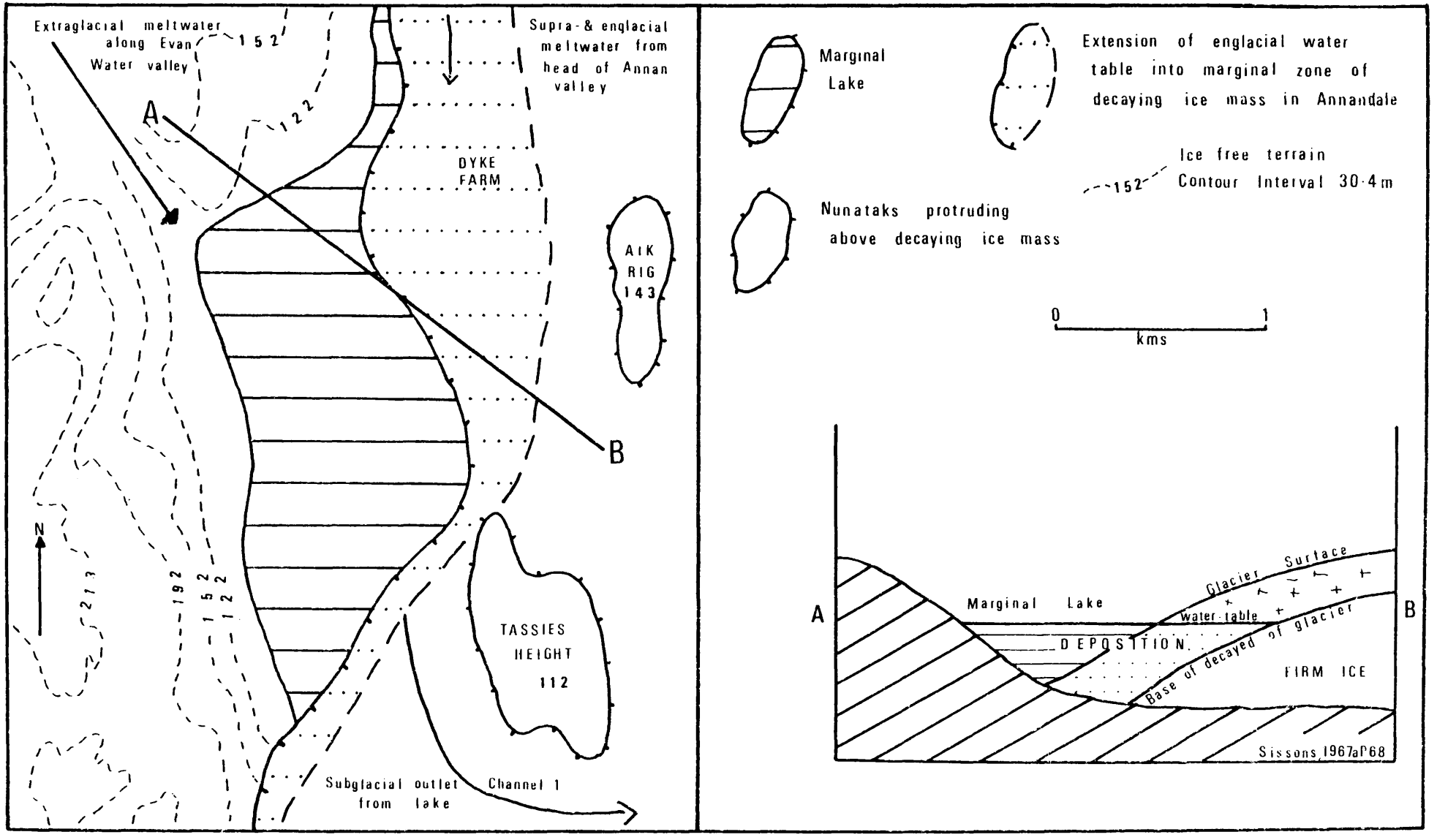


Fig. 3.38. Formation of fluvioglacial landforms at Tassies Height.

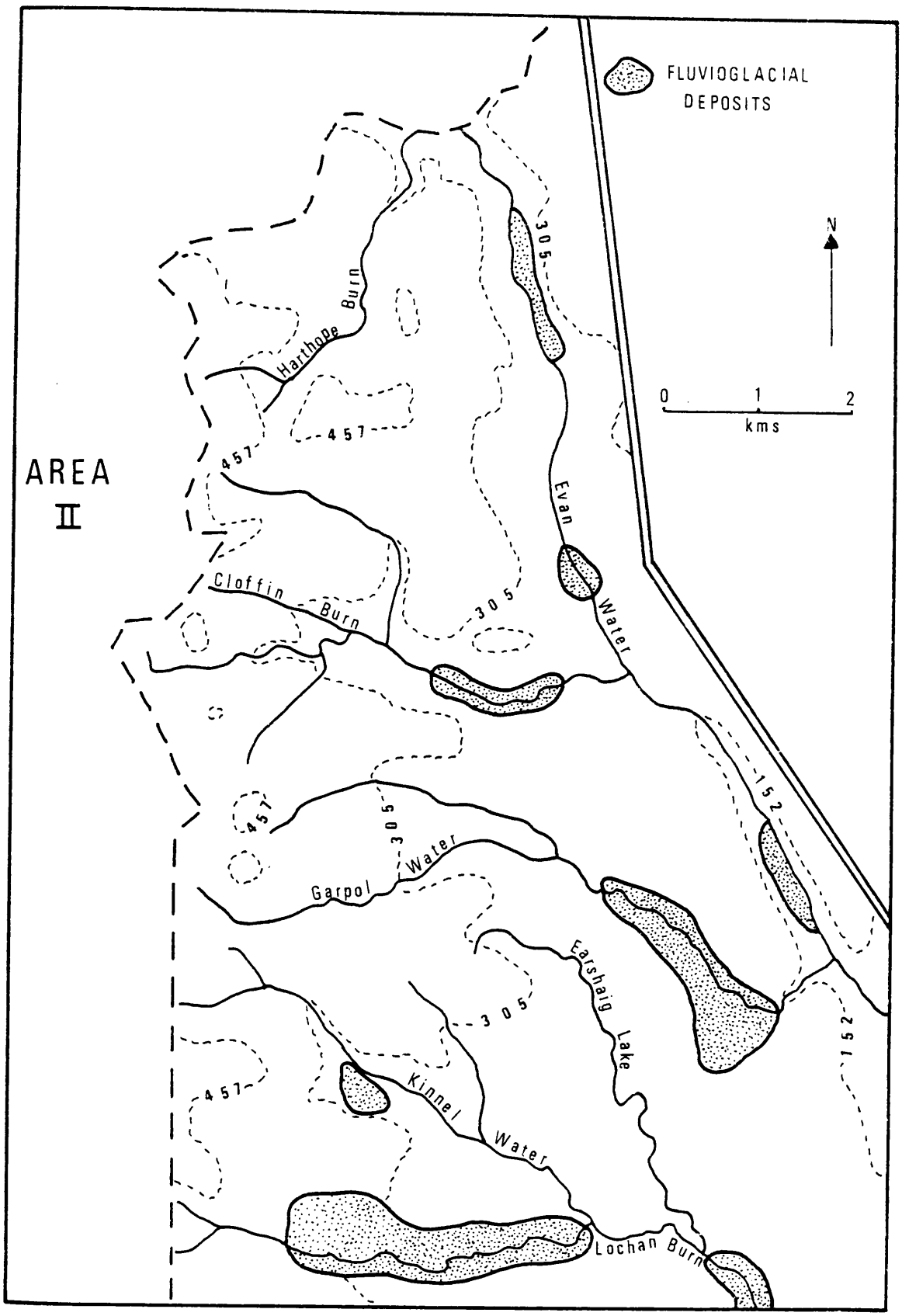


Fig. 3.39. Fluvioglacial deposits in the vicinity of the Evan Water valley.

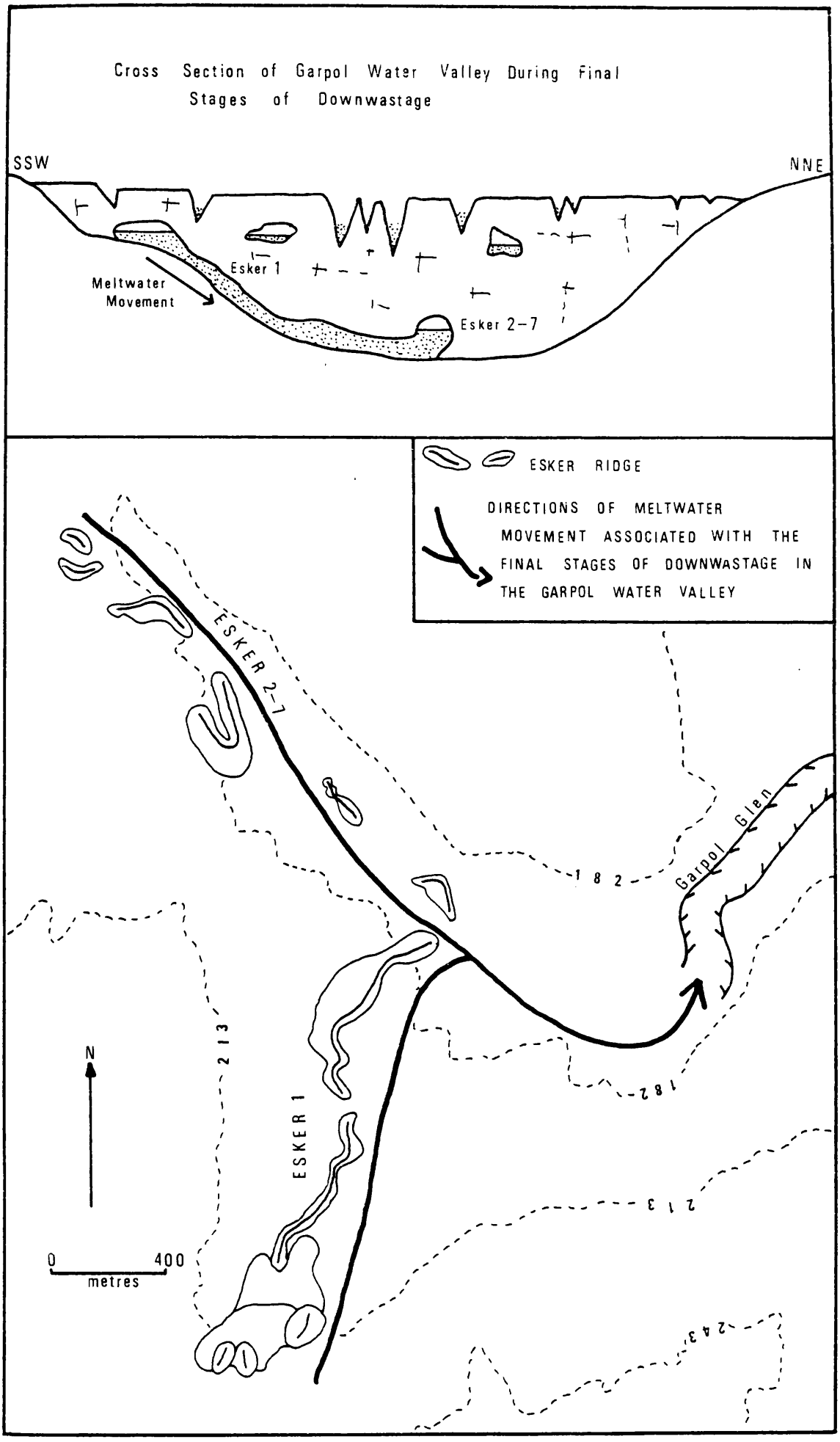


Fig. 3.40. Glacial and fluvioglacial conditions in the Garpol Water valley during the final stages of downwastage.

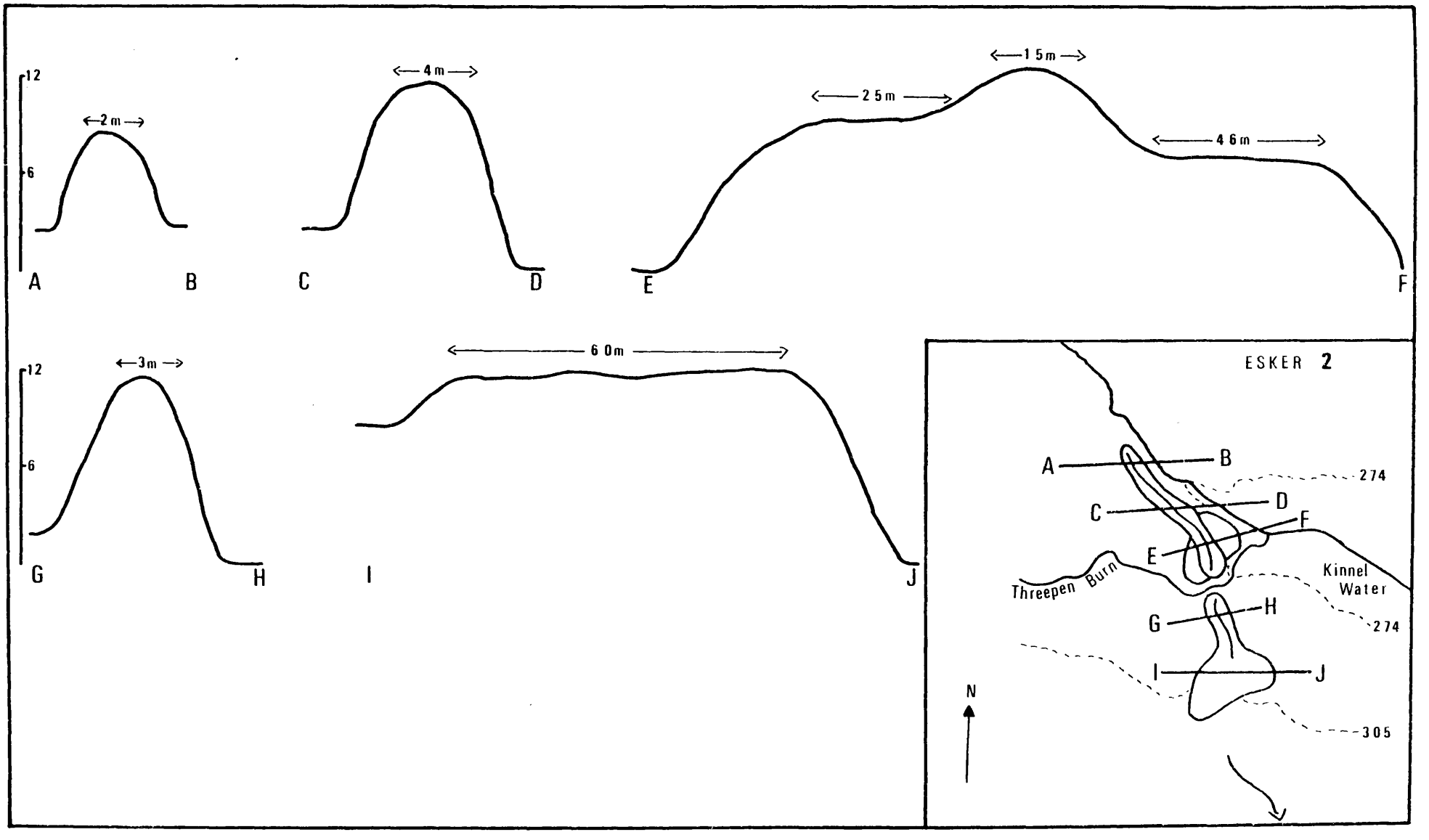


Fig. 3.41. Cross-sections of esker 2 in Kinnel Water valley.

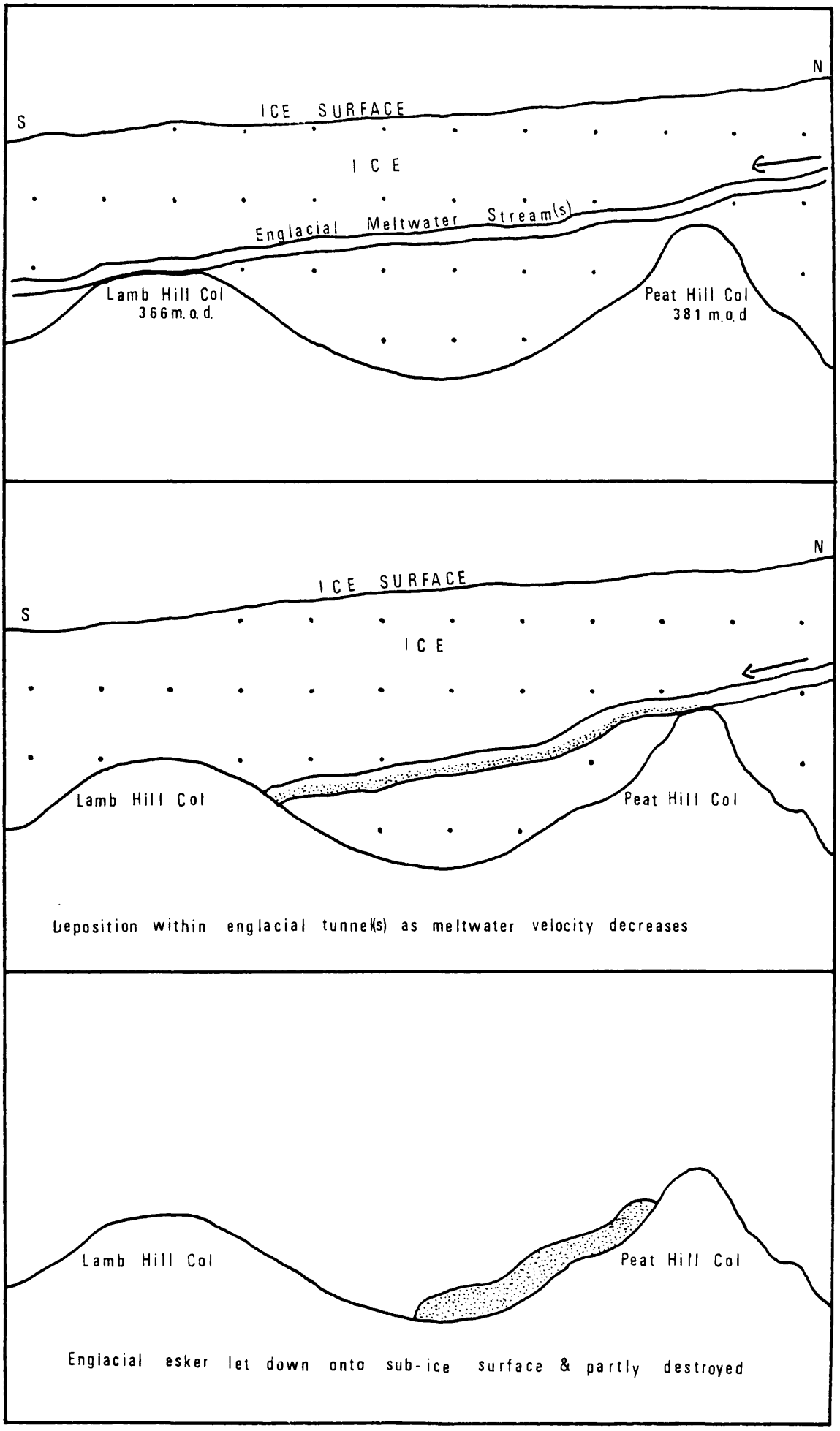


Fig. 3.42. Formation of esker 1 in Lecket Valley.

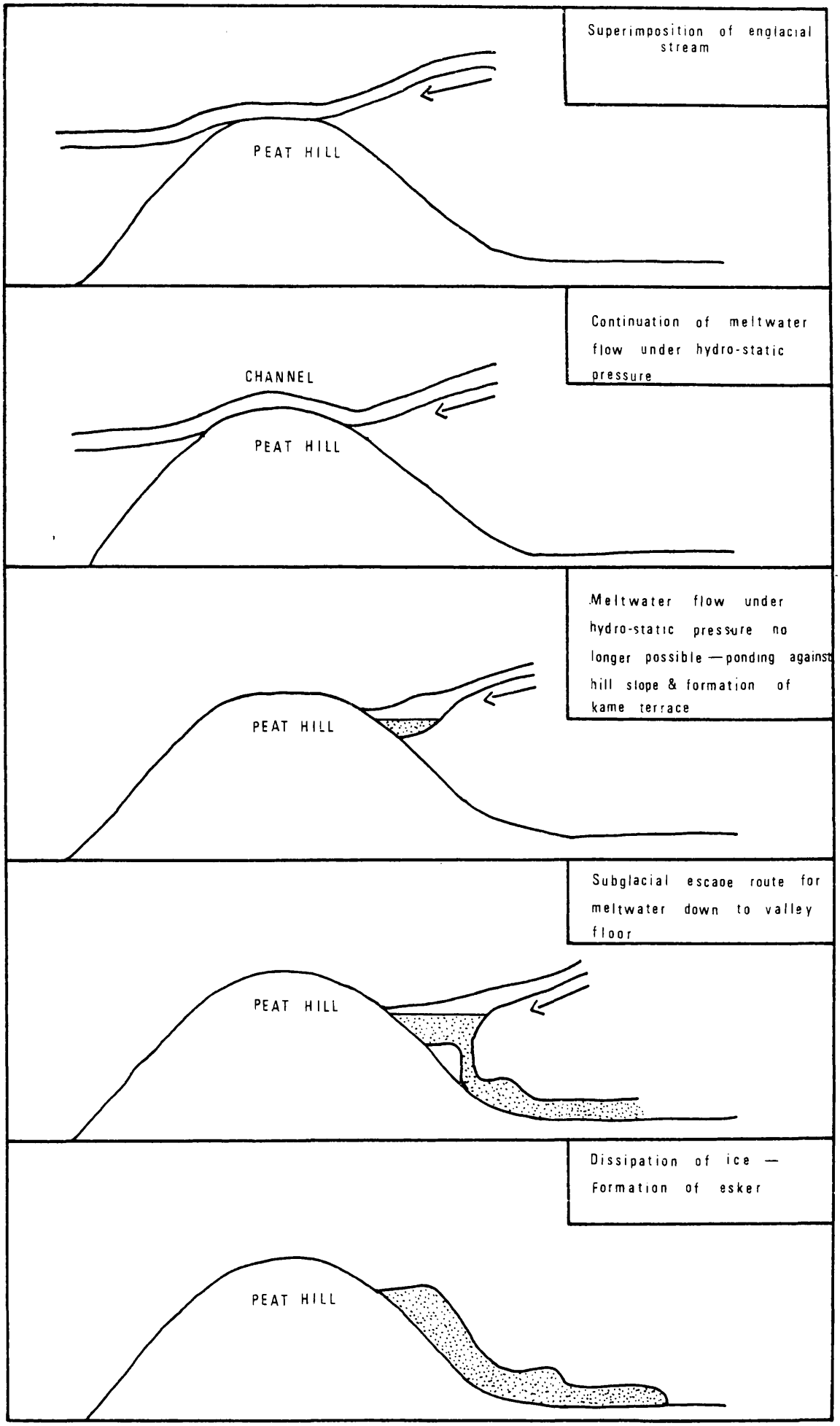


Fig. 3.43. Formation of esker 2 and channel XX5, Kinnel Water valley.

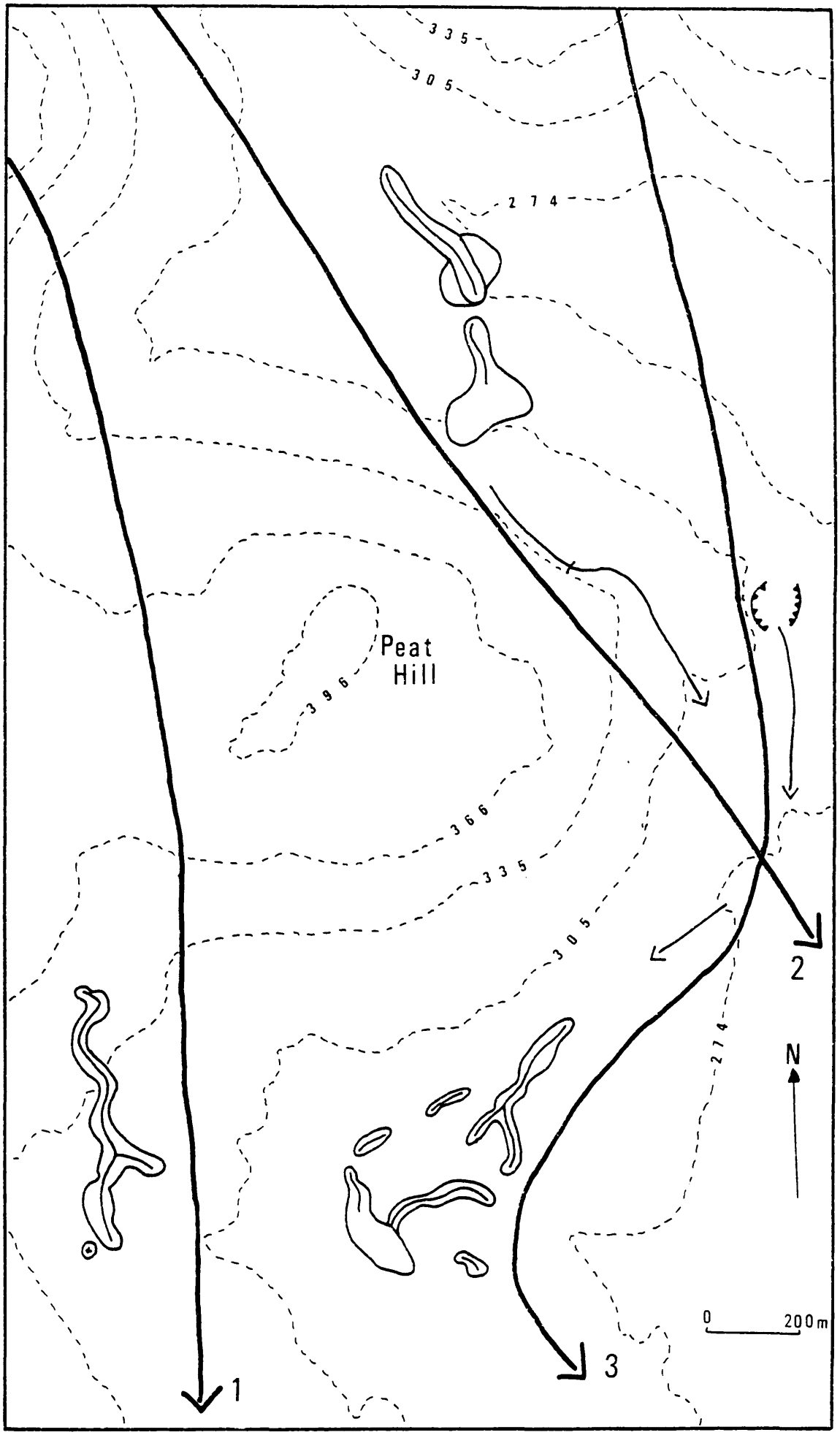


Fig. 3.47. Changing course of meltwater drainage in vicinity of Peat Hill during deglaciation.

MAPS AND DIAGRAMS - CHAPTER 4.

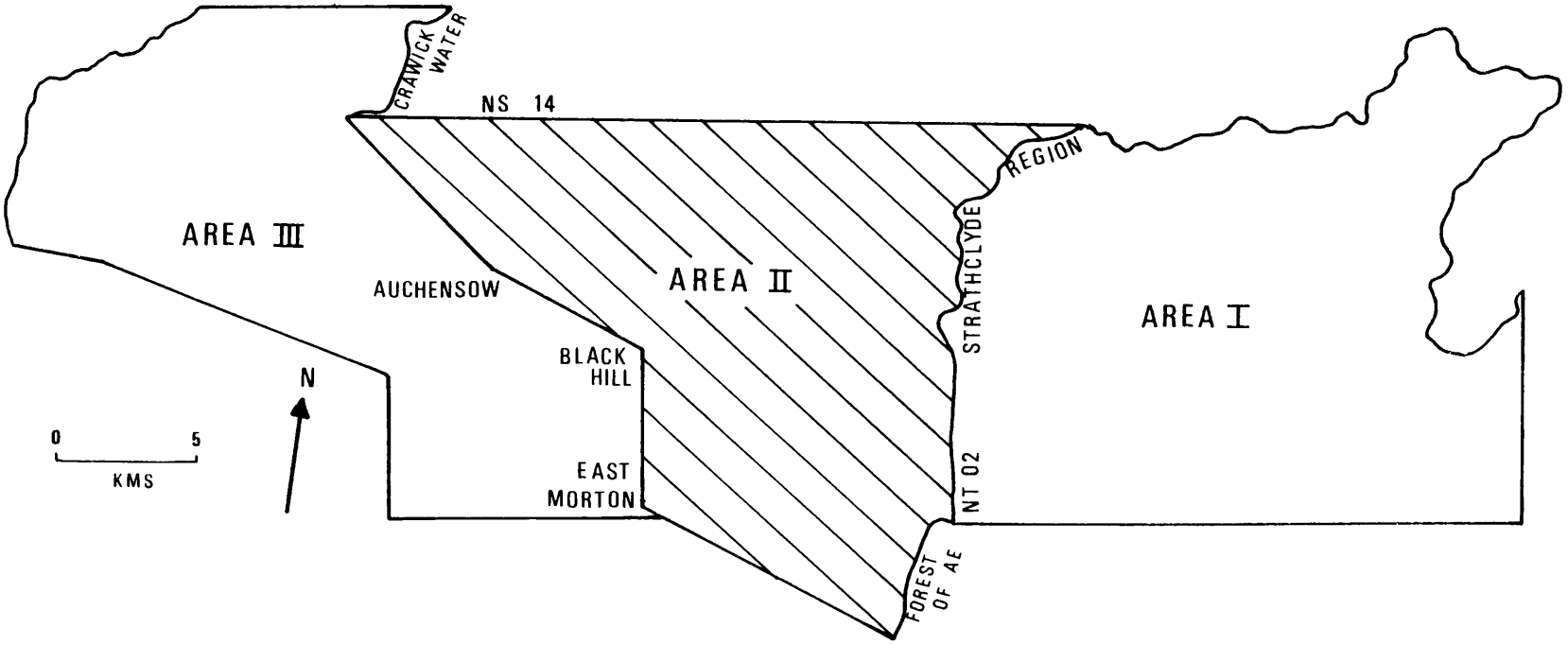


Fig. 4.1. Area II - Location and extent.

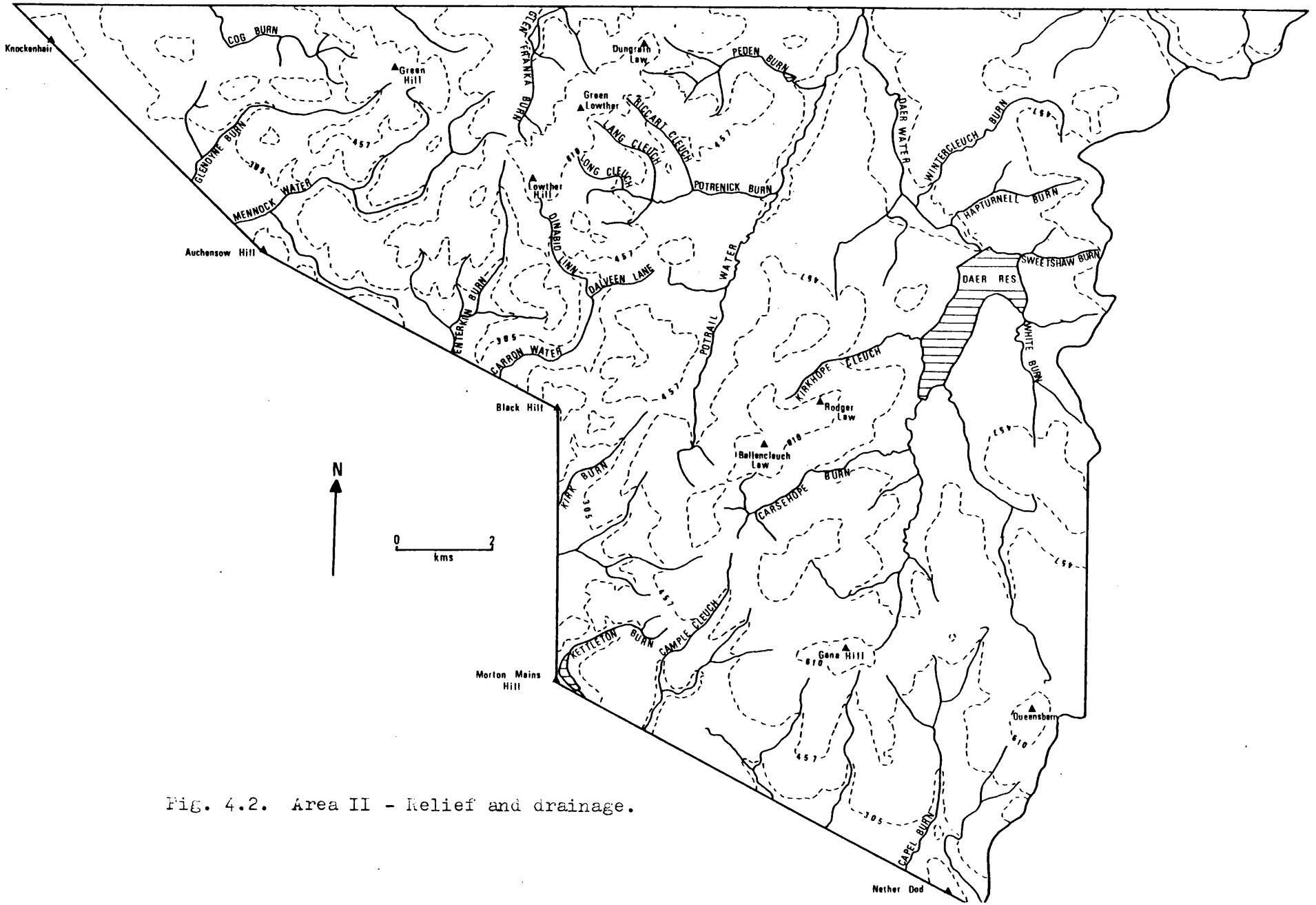


Fig. 4.2. Area II - Relief and drainage.

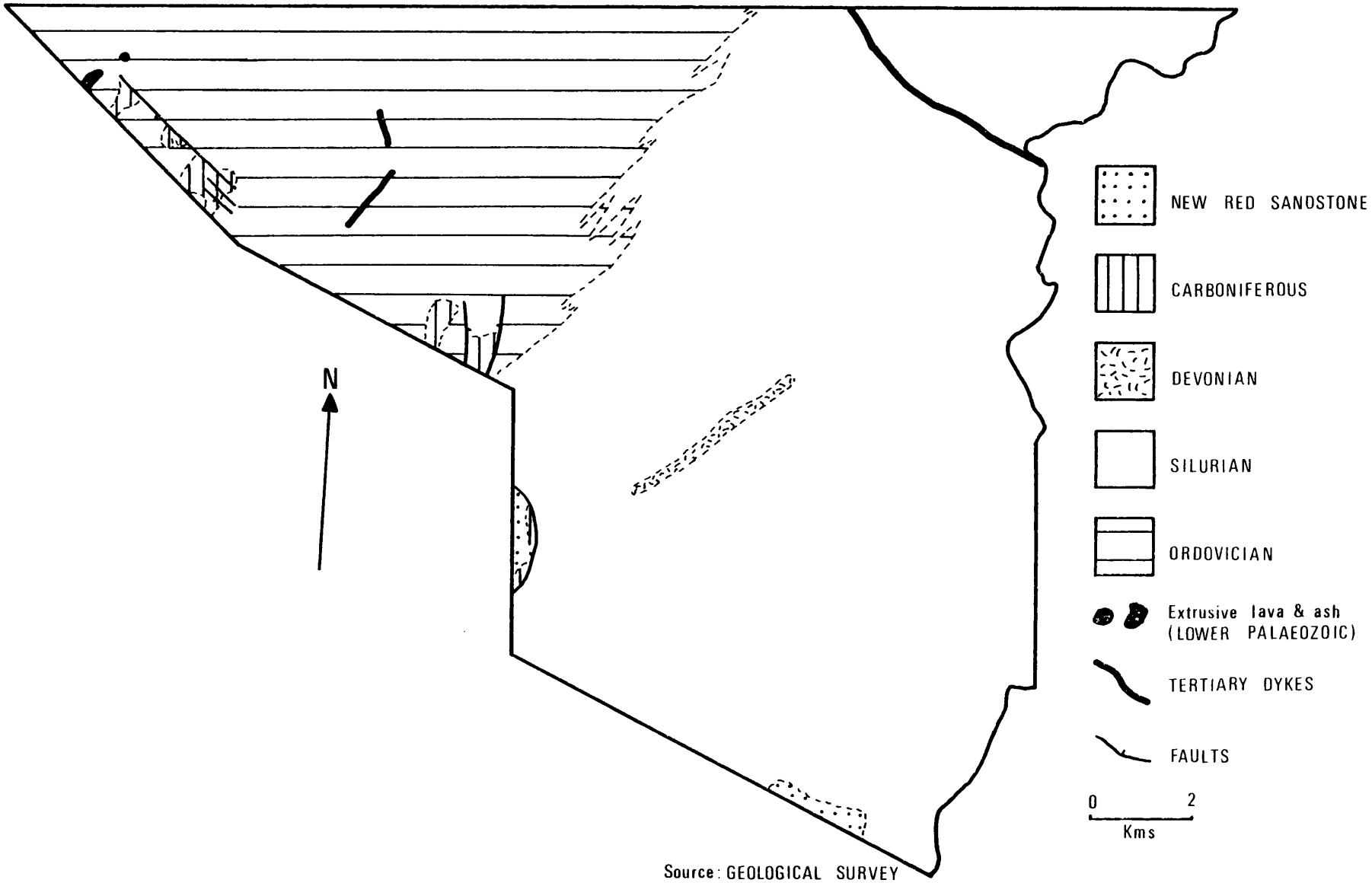


Fig. 4.3. Area II - Geology.

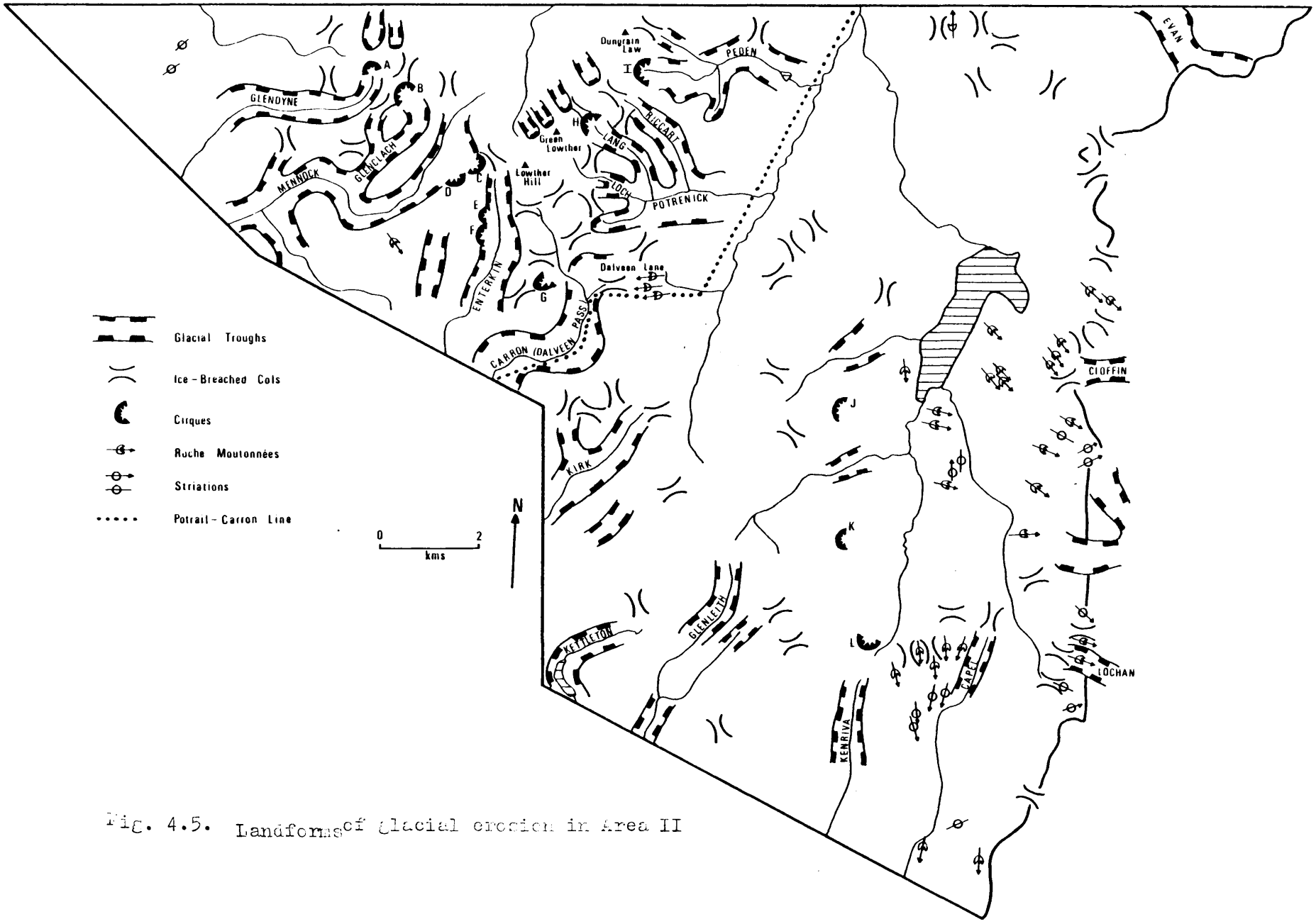


Fig. 4.5. Landforms of glacial erosion in Area II

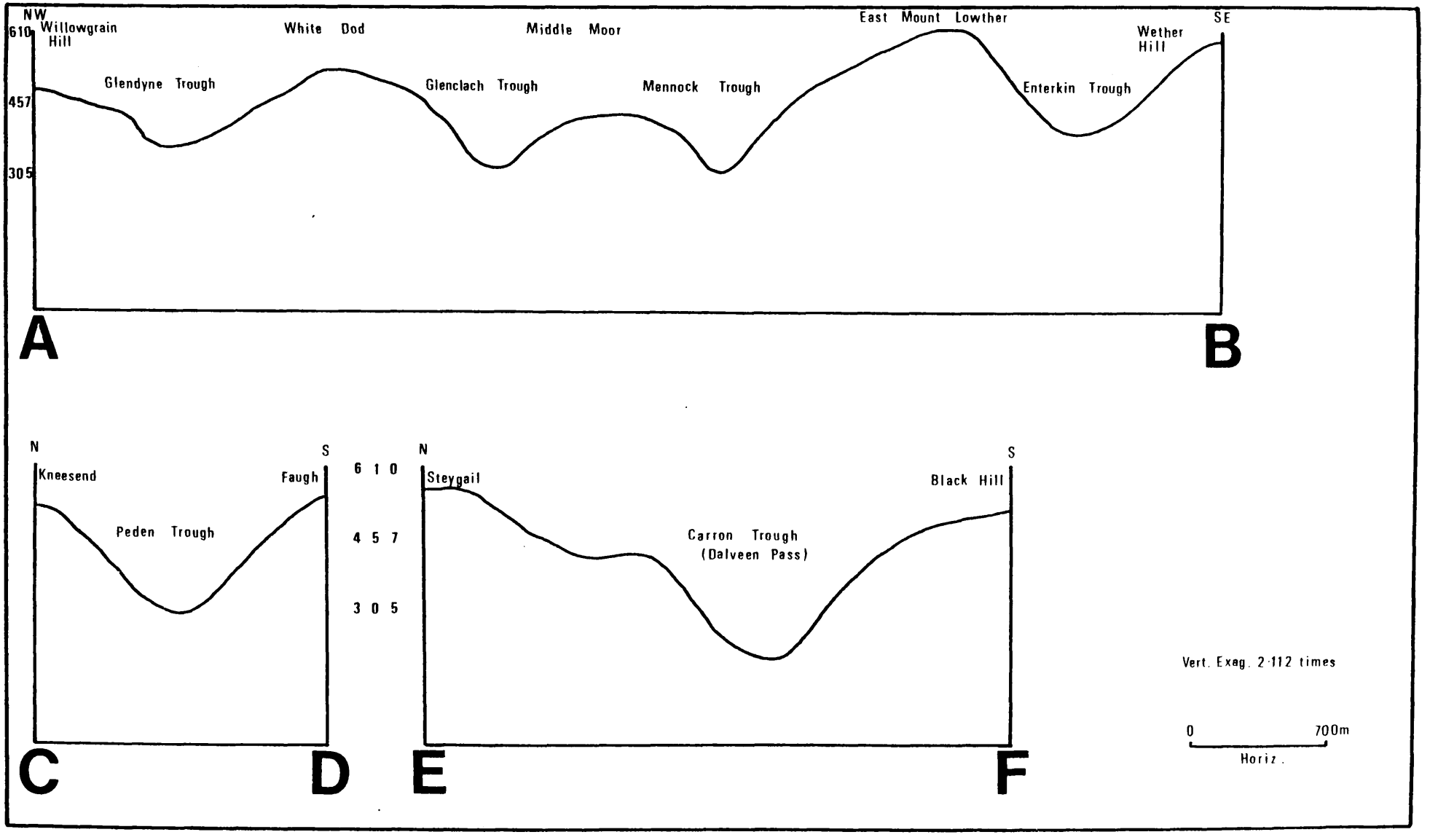


Fig. 4.6. Area II - Cross-sections.

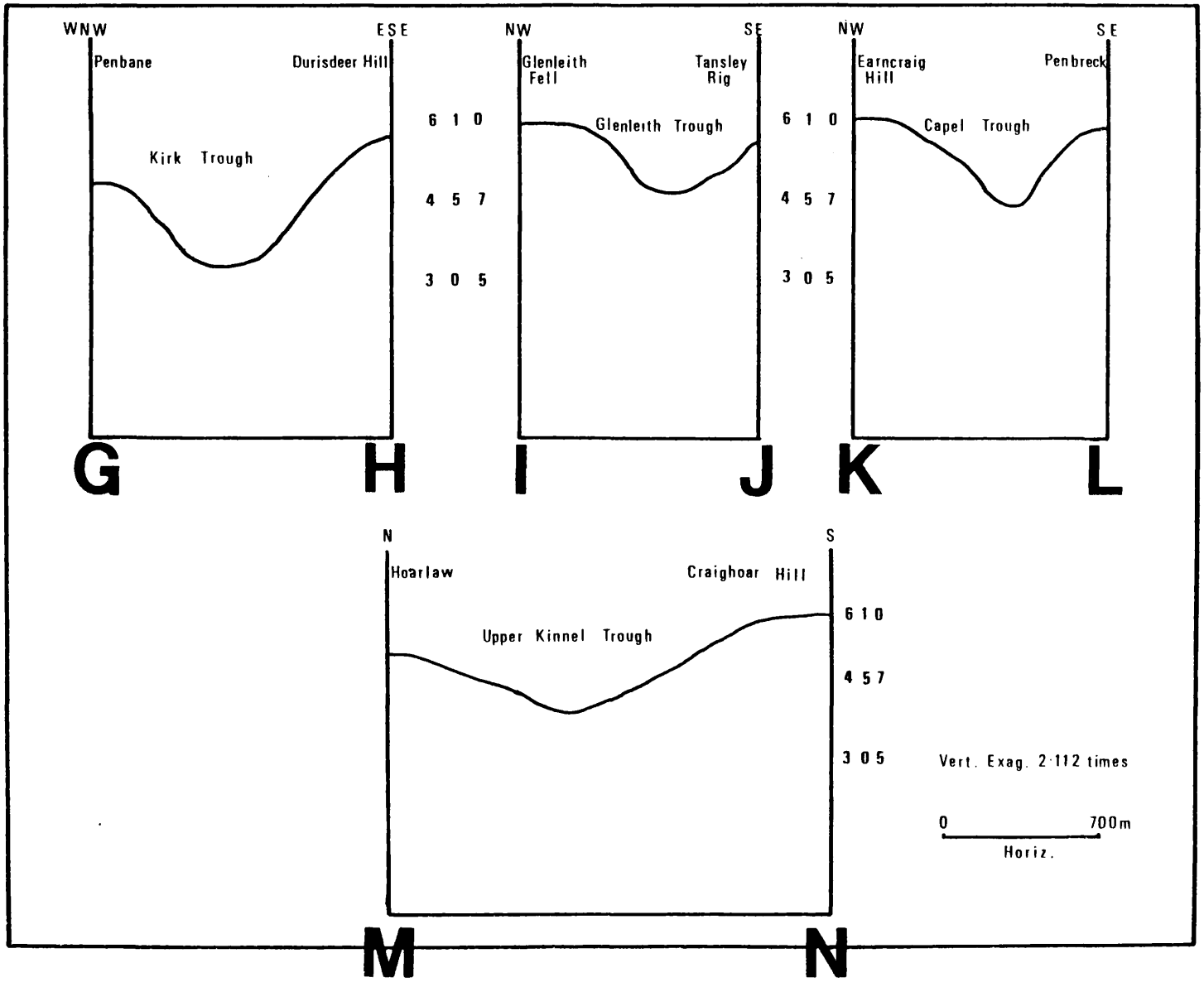
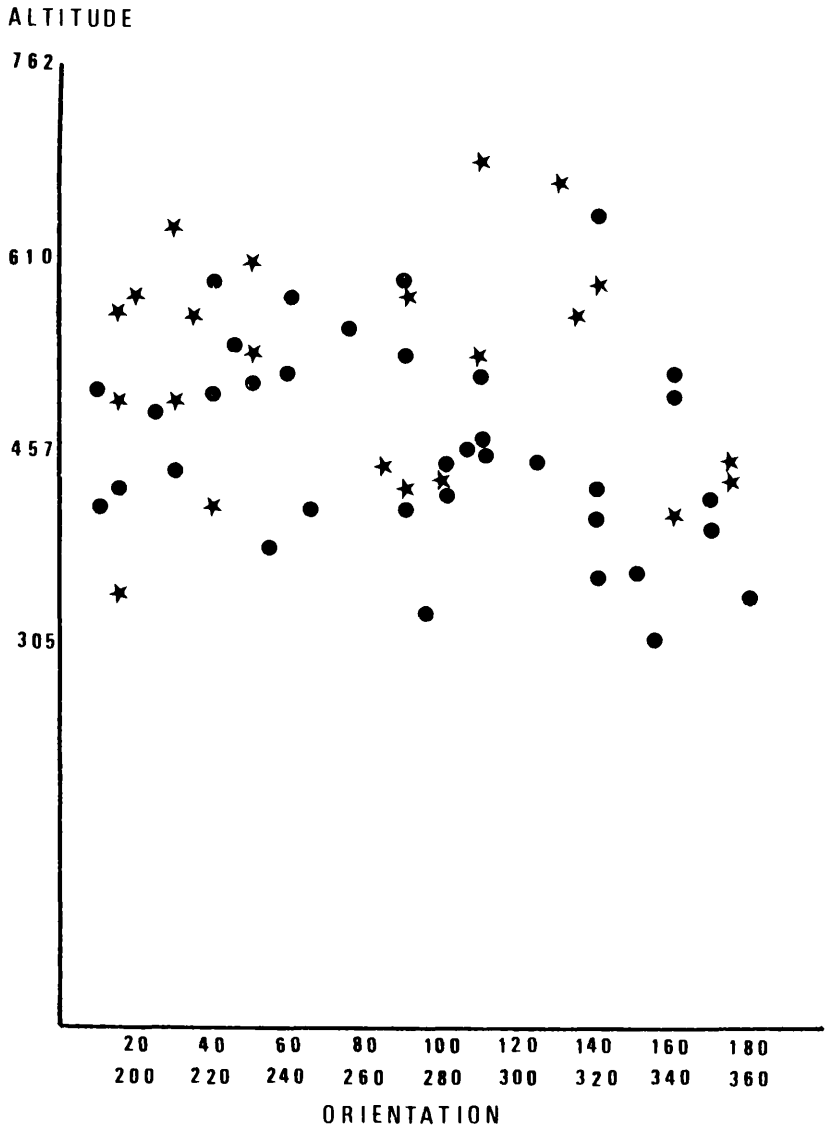


Fig. 4.6. continued.



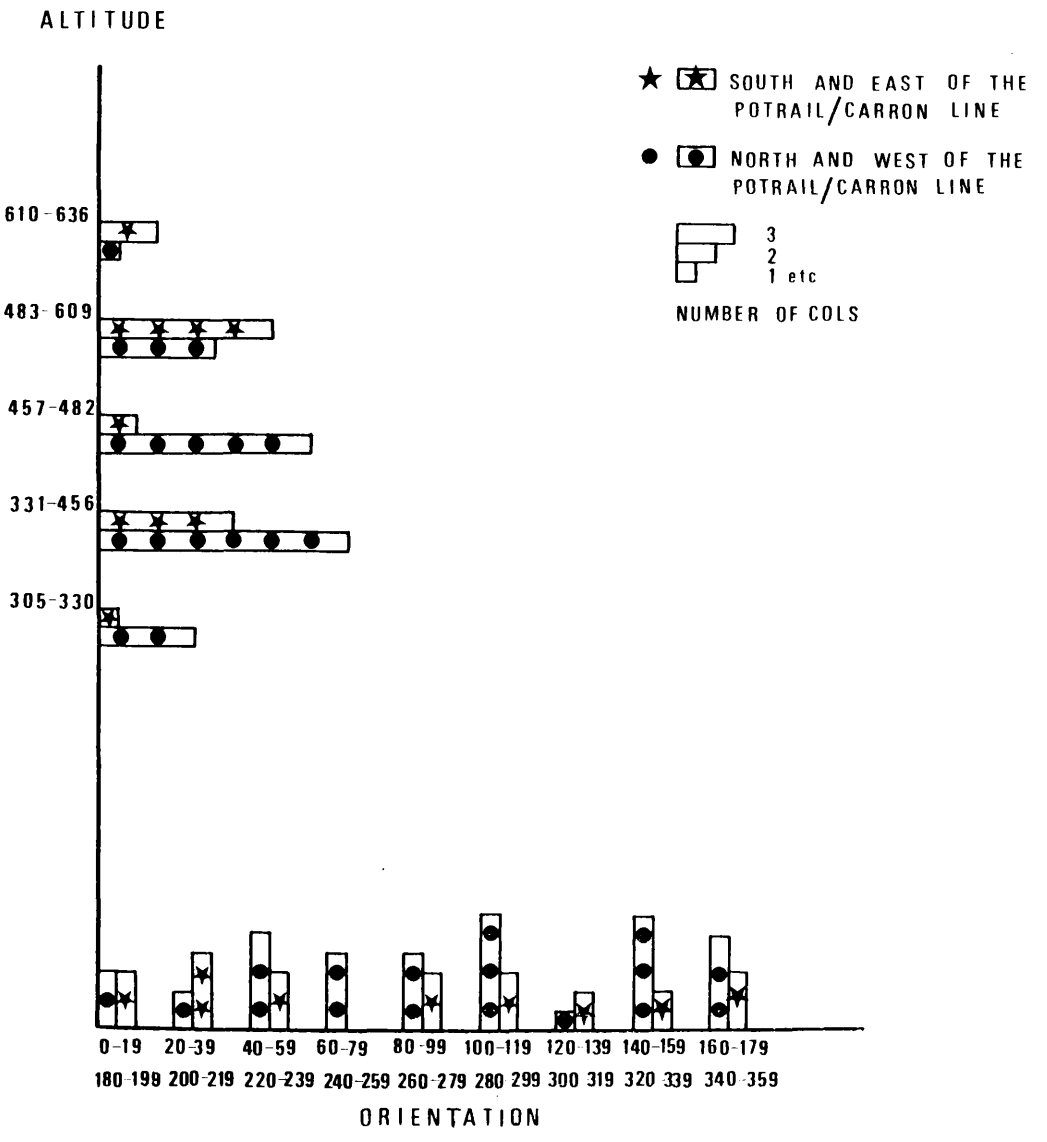


Fig. 4.7. Area II - Altitude and alignment of cols.

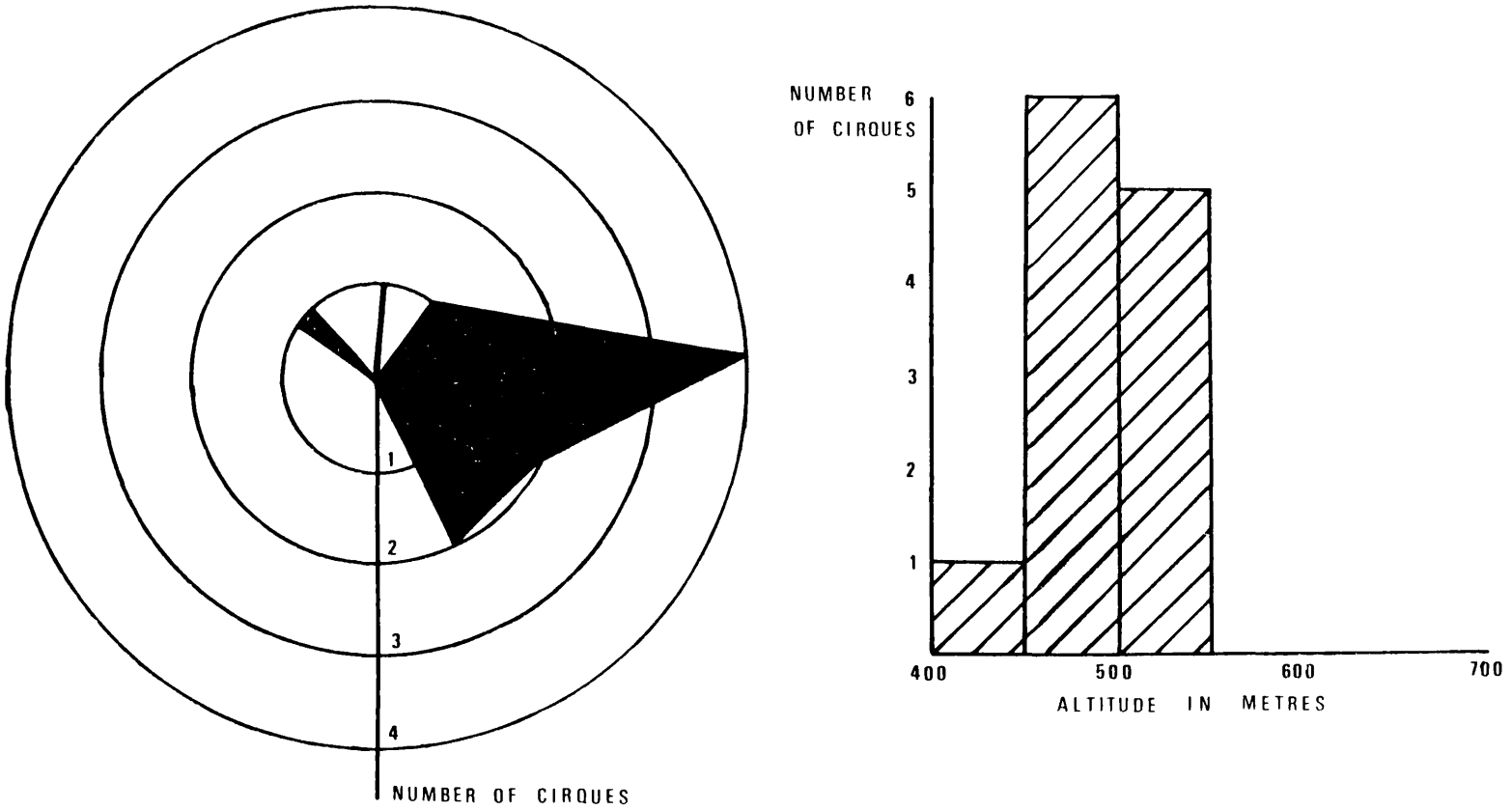


Fig. 4.c. Altitude and orientation of cirques.

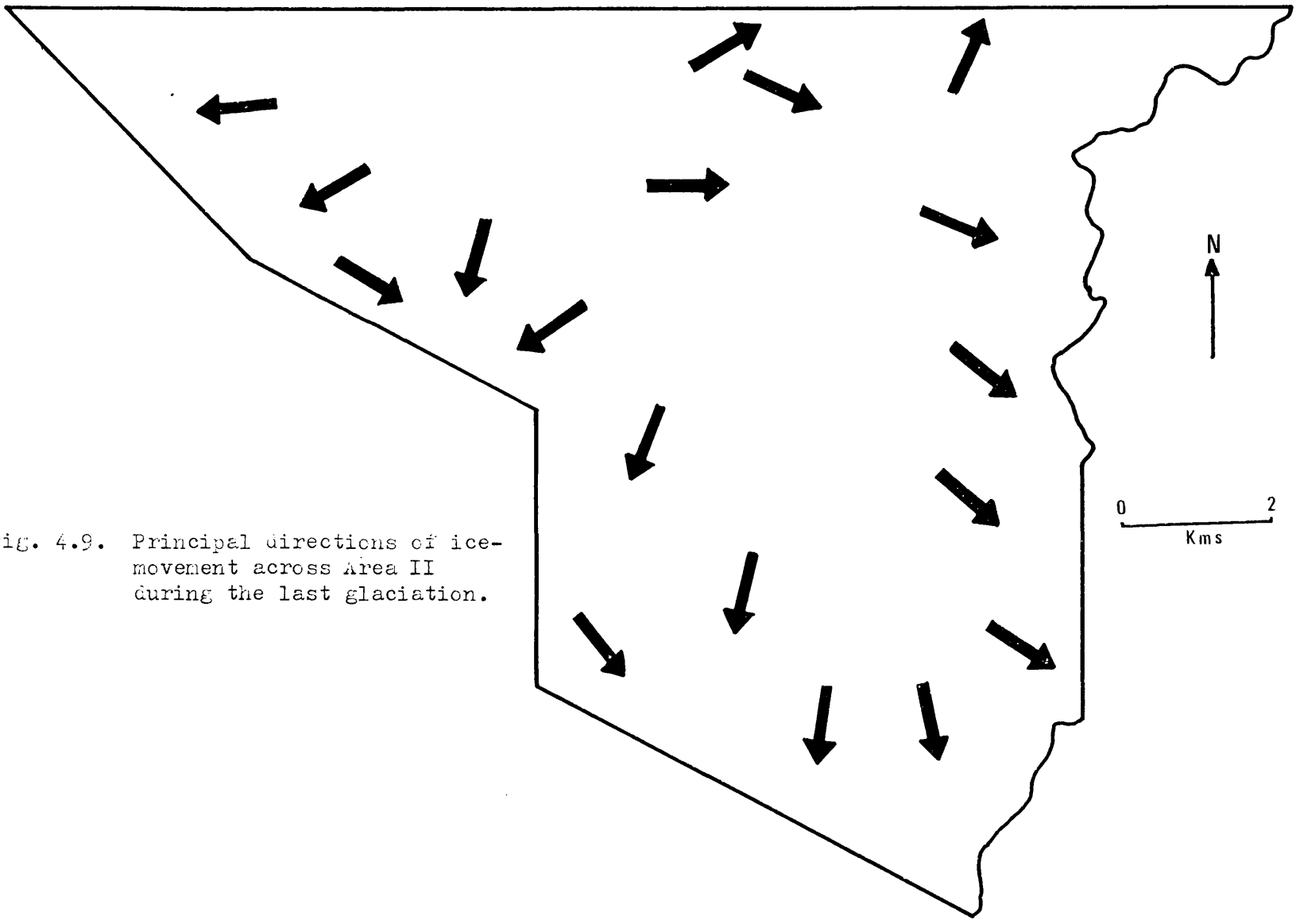


Fig. 4.9. Principal directions of ice-movement across Area II during the last glaciation.

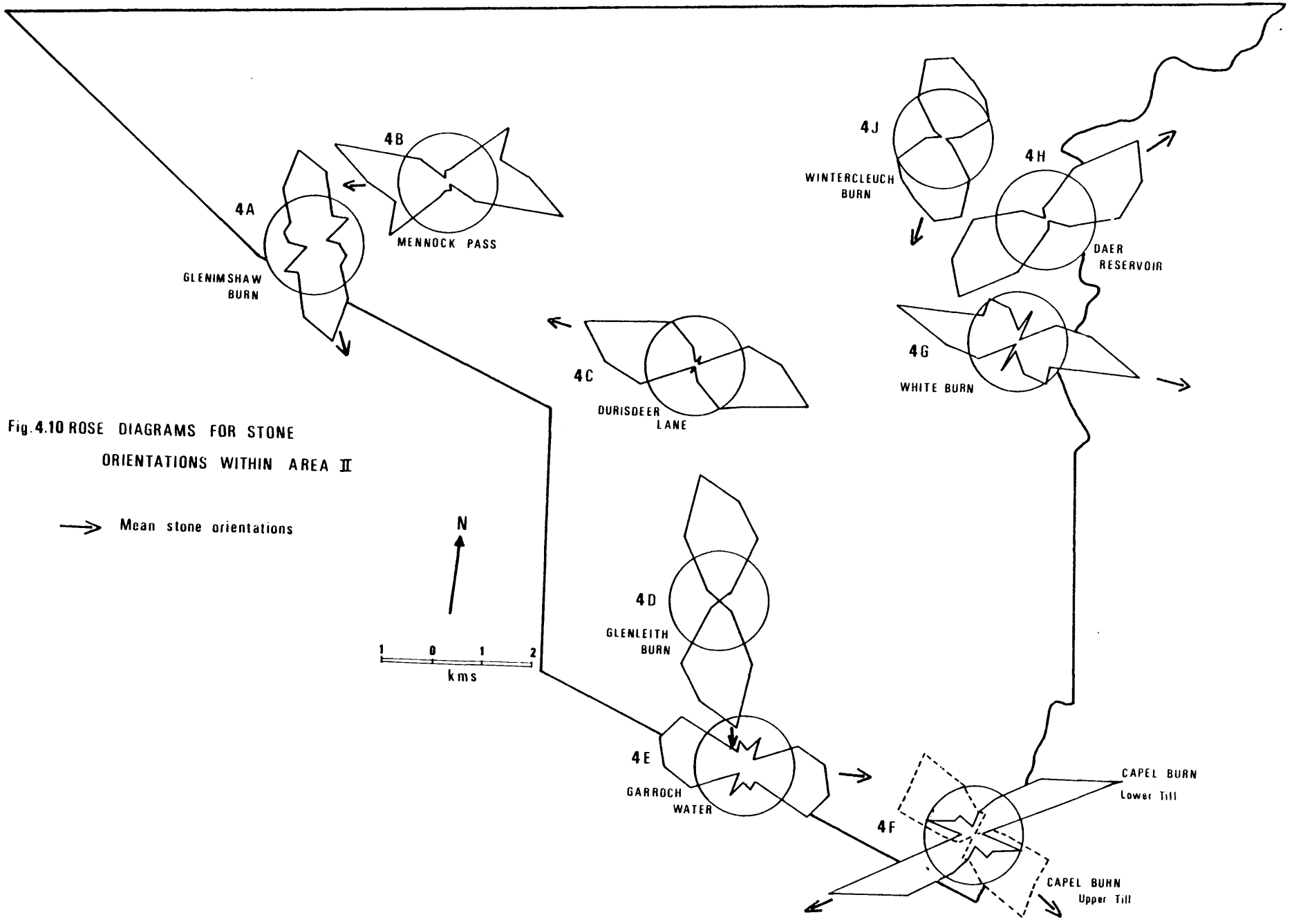


Fig. 4.10 ROSE DIAGRAMS FOR STONE ORIENTATIONS WITHIN AREA II

→ Mean stone orientations

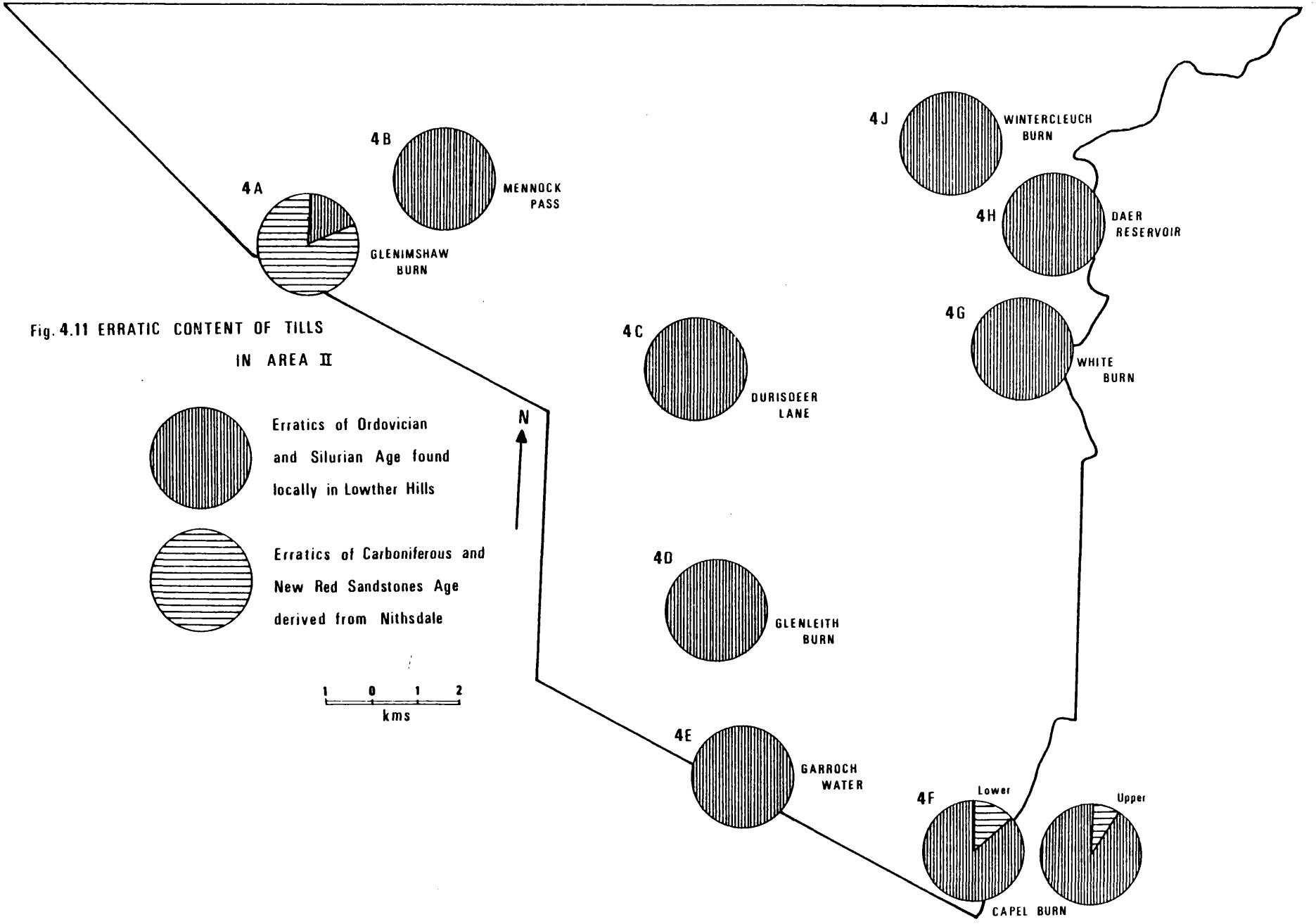


Fig. 4.11 ERRATIC CONTENT OF TILLS IN AREA II

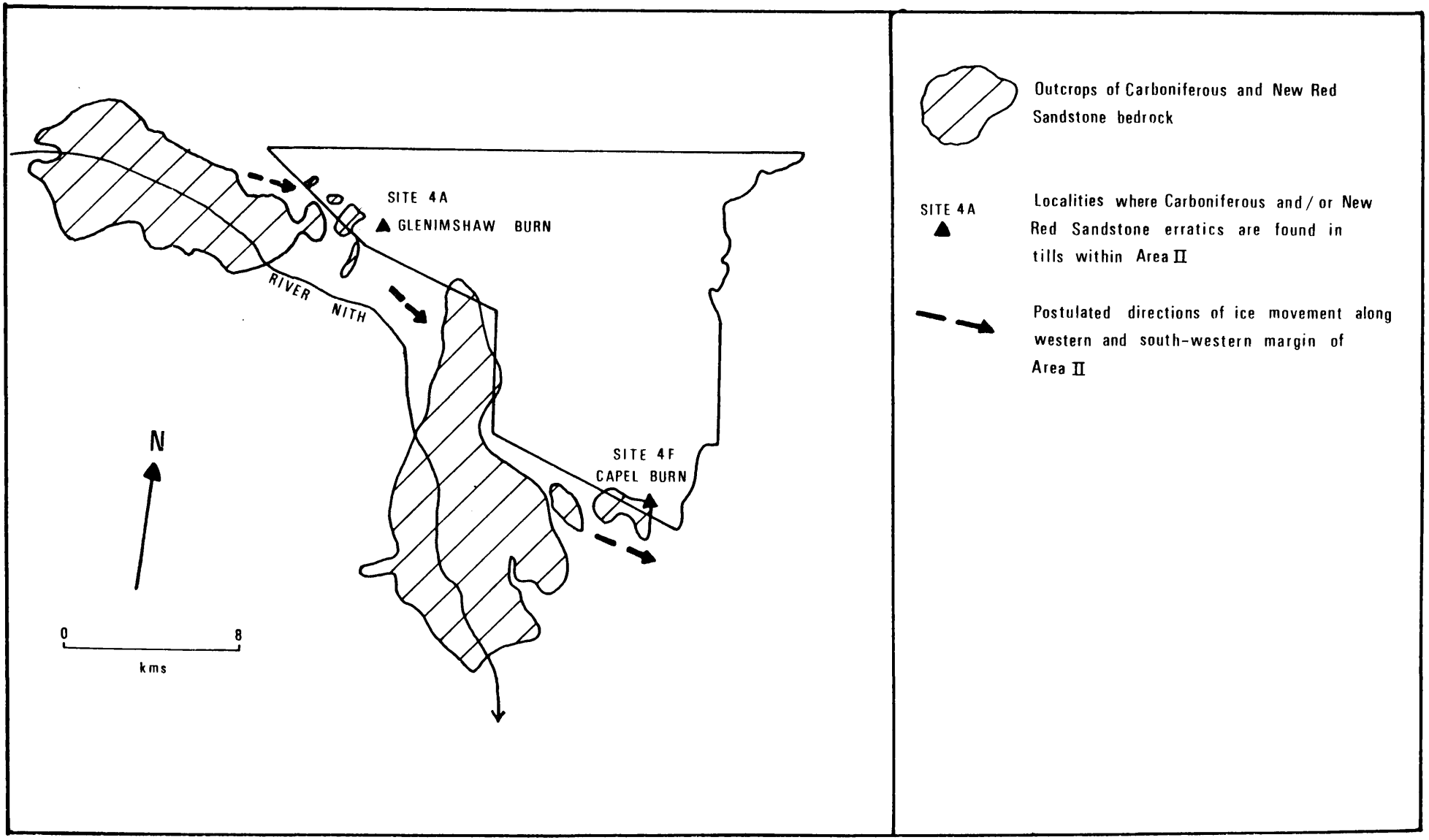


Fig. 4.12. Carboniferous and New Red Sandstone outcrops in the vicinity of Area II.

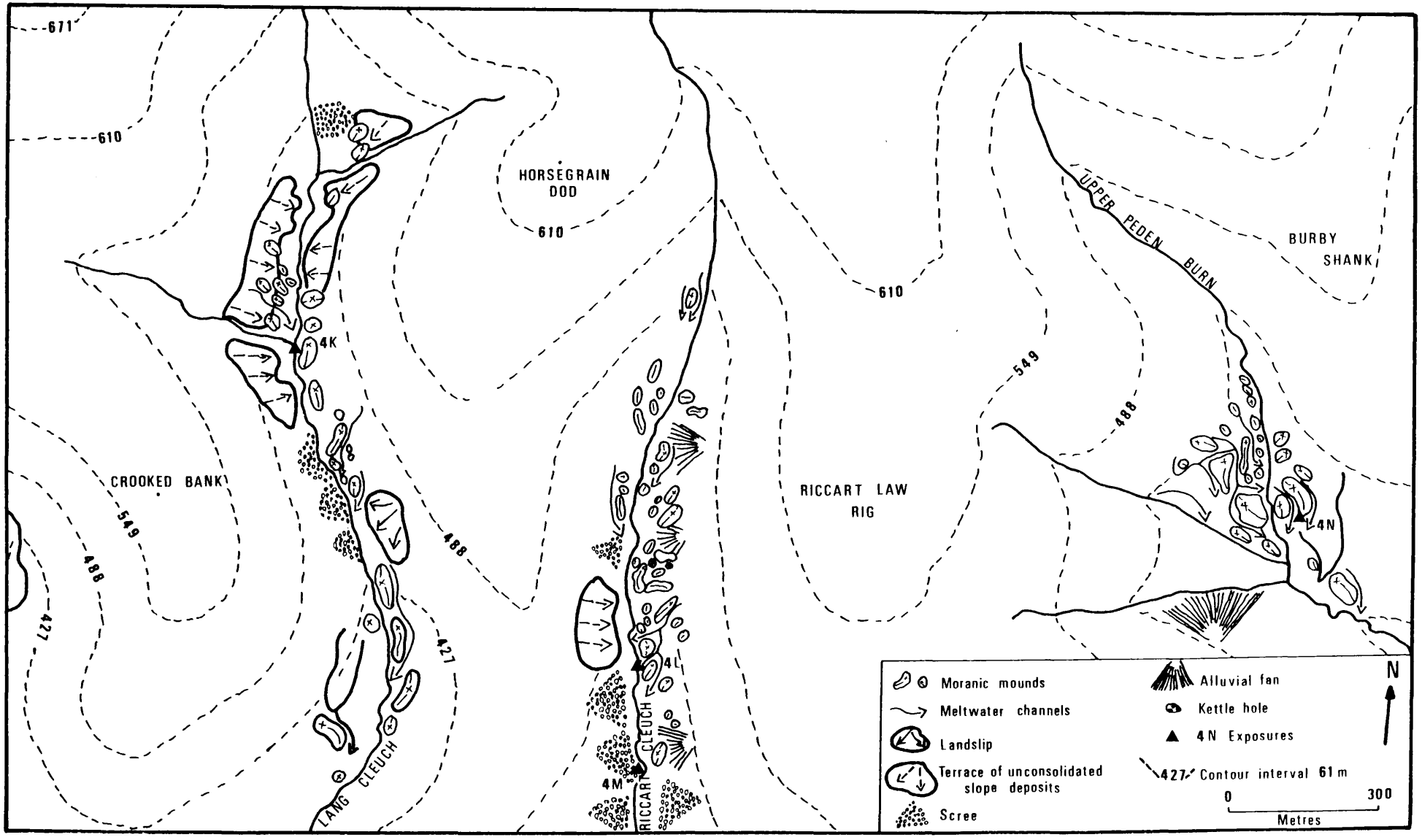


Fig. 4.13. Morainic landforms in Area II.

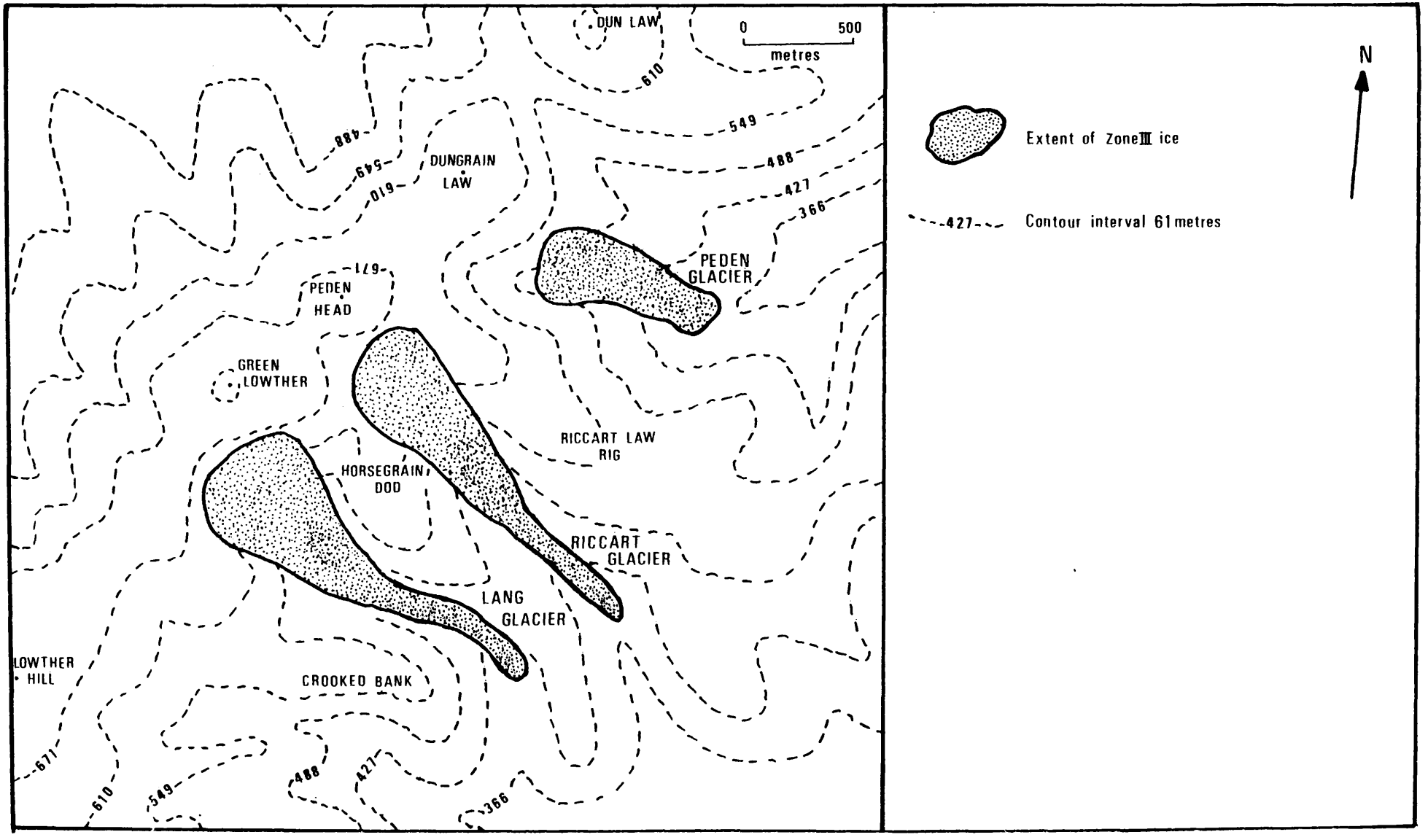


Fig. 4.14. Extent of Zone III glaciers in the Lowther Hills.

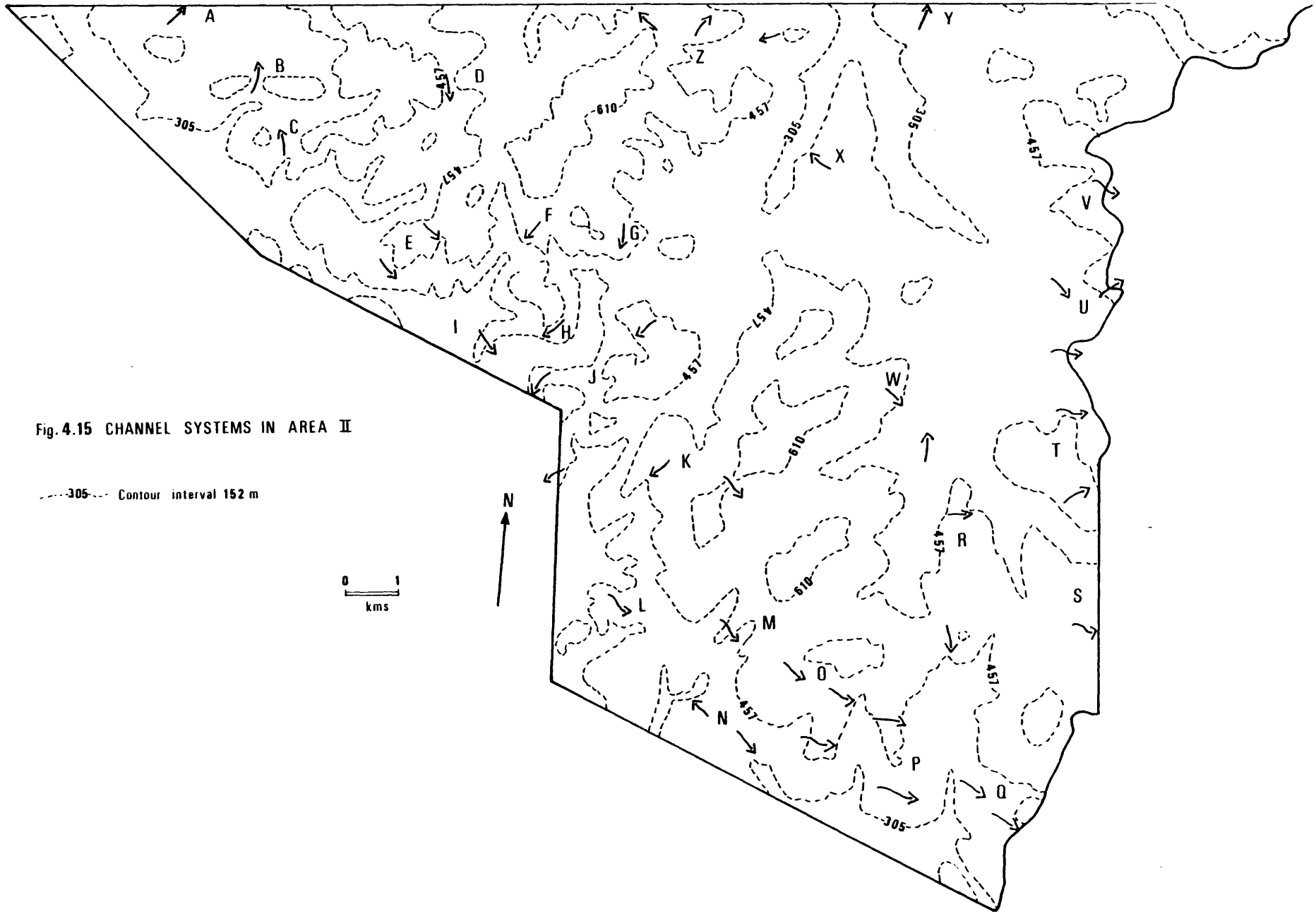


Fig. 4.15 CHANNEL SYSTEMS IN AREA II

305 Contour interval 152 m

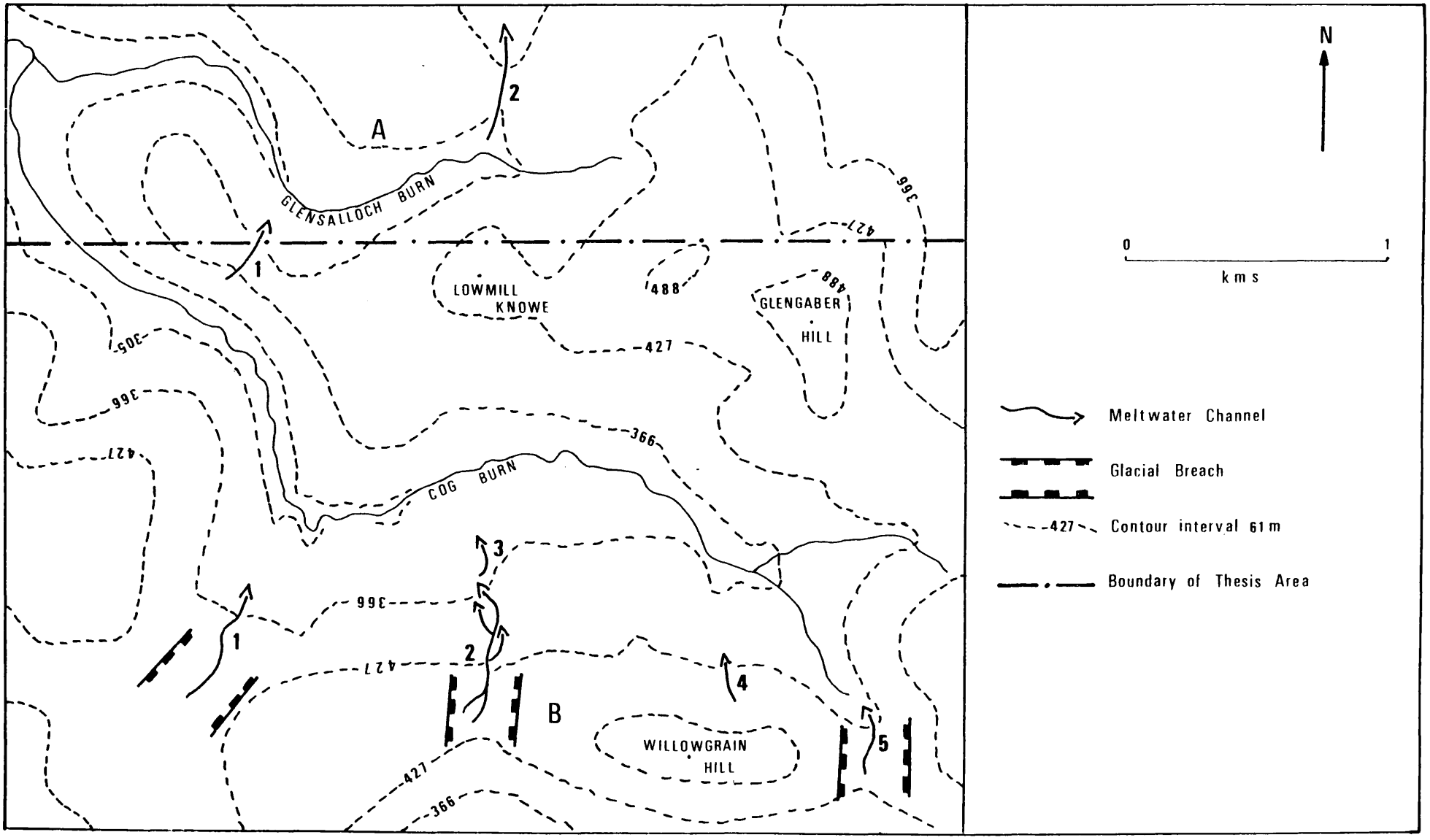


Fig. 4.16. Channel system 3.

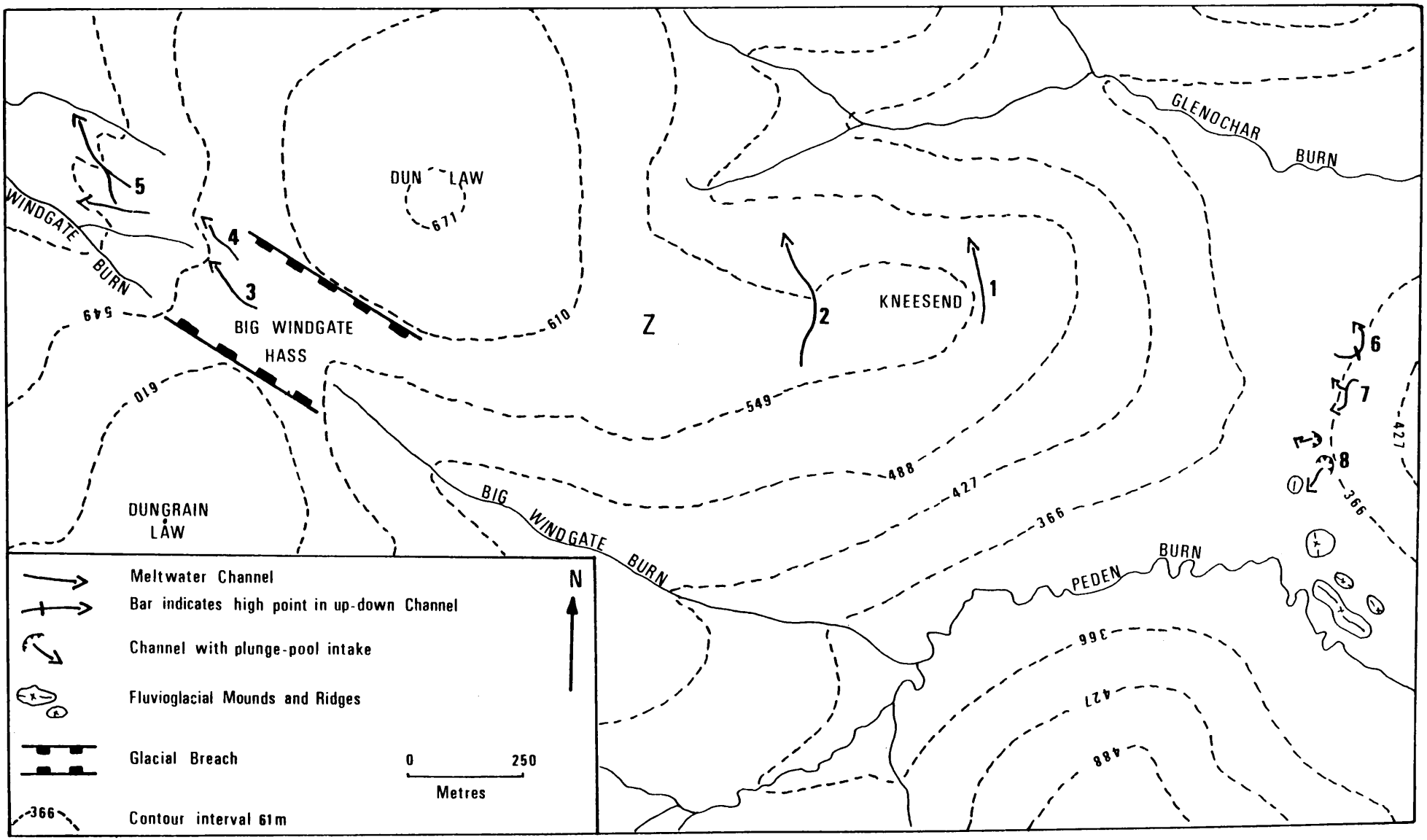


Fig. 4.17. Channel system Z.

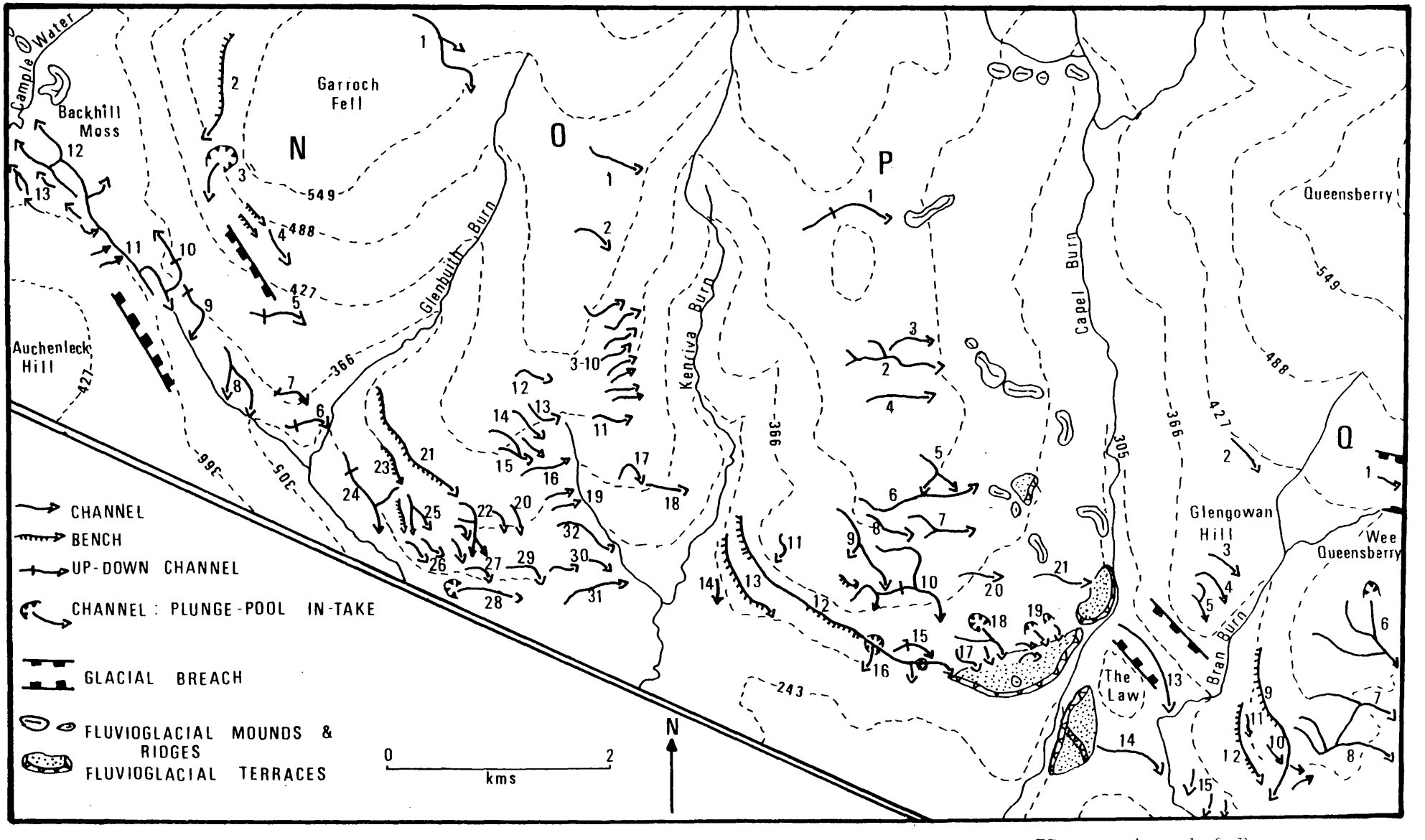


Fig. 4.18. Channels along the south and south-west boundry of Area II - systems N,O,P,..

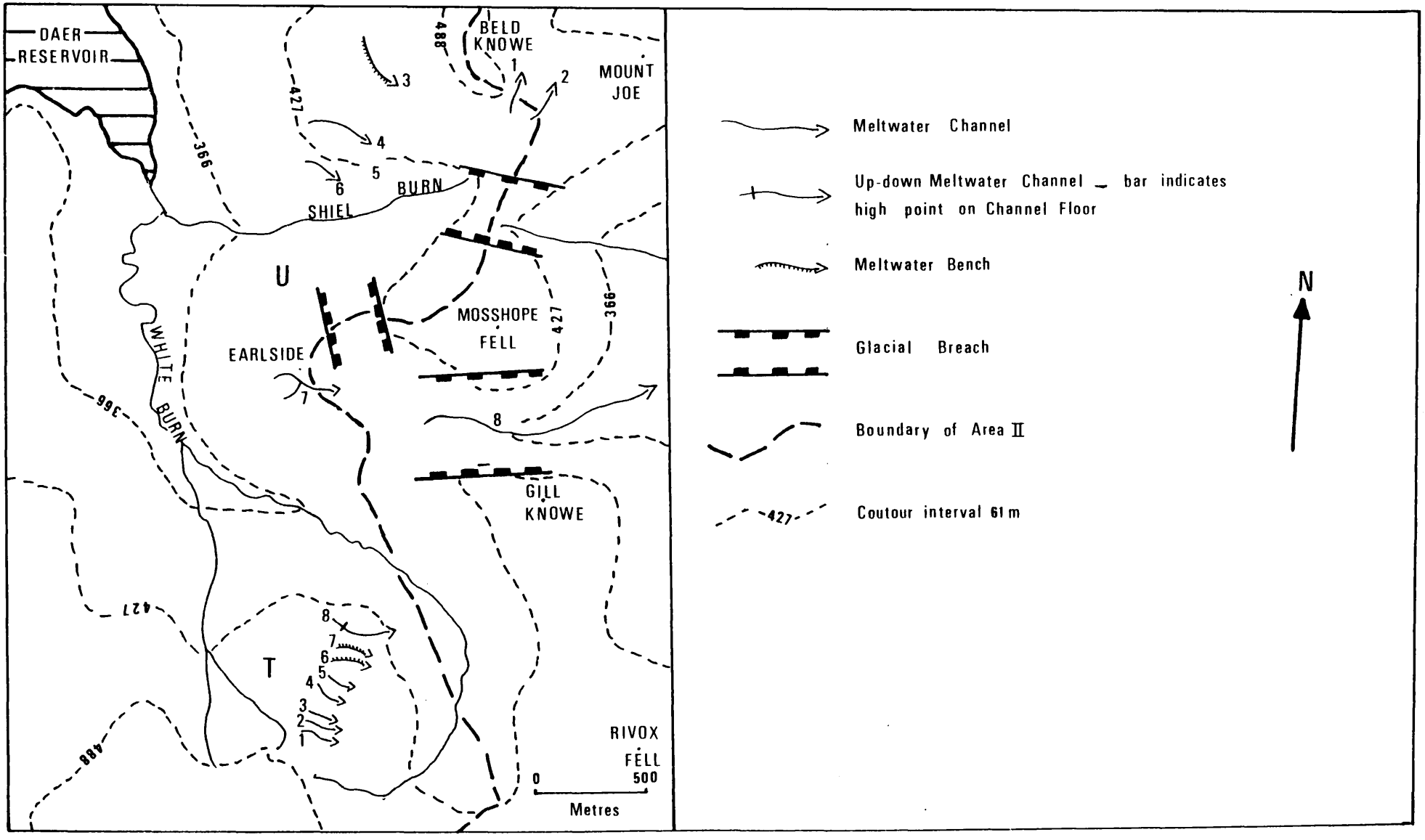


Fig. 4.19. Channel system U.

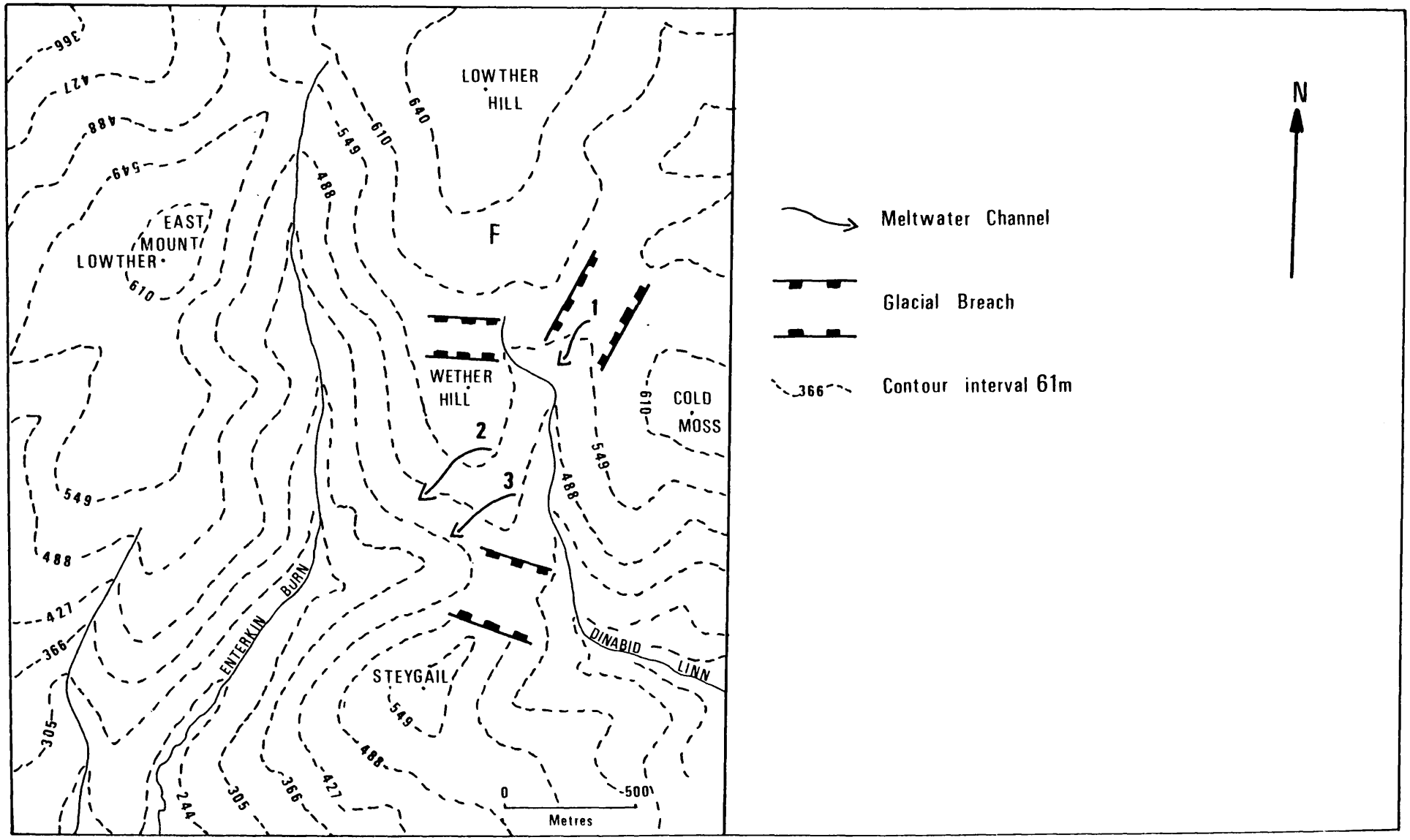


Fig. 4.20. Channel system F.

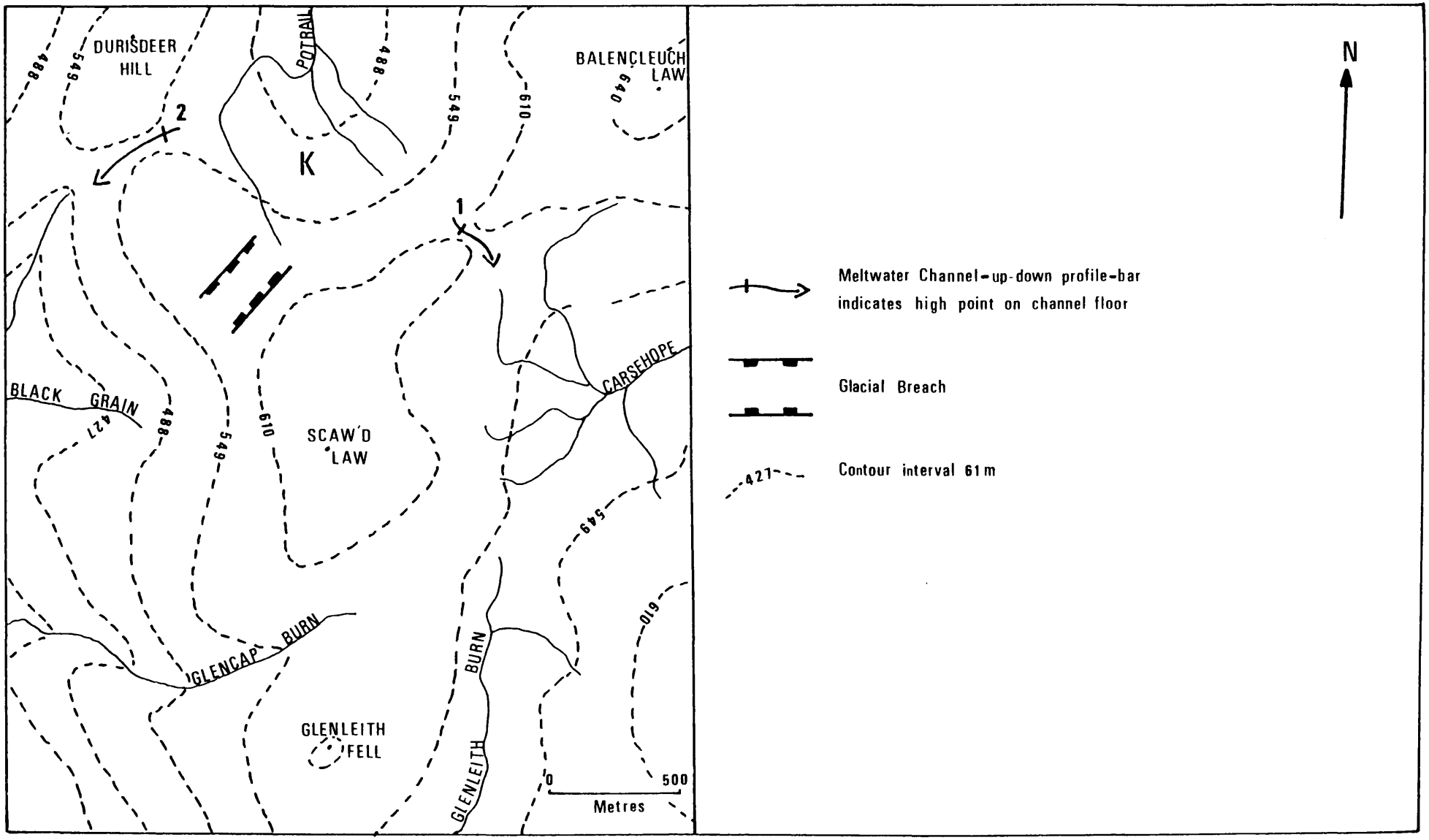


Fig. 4.21. Channel system K.

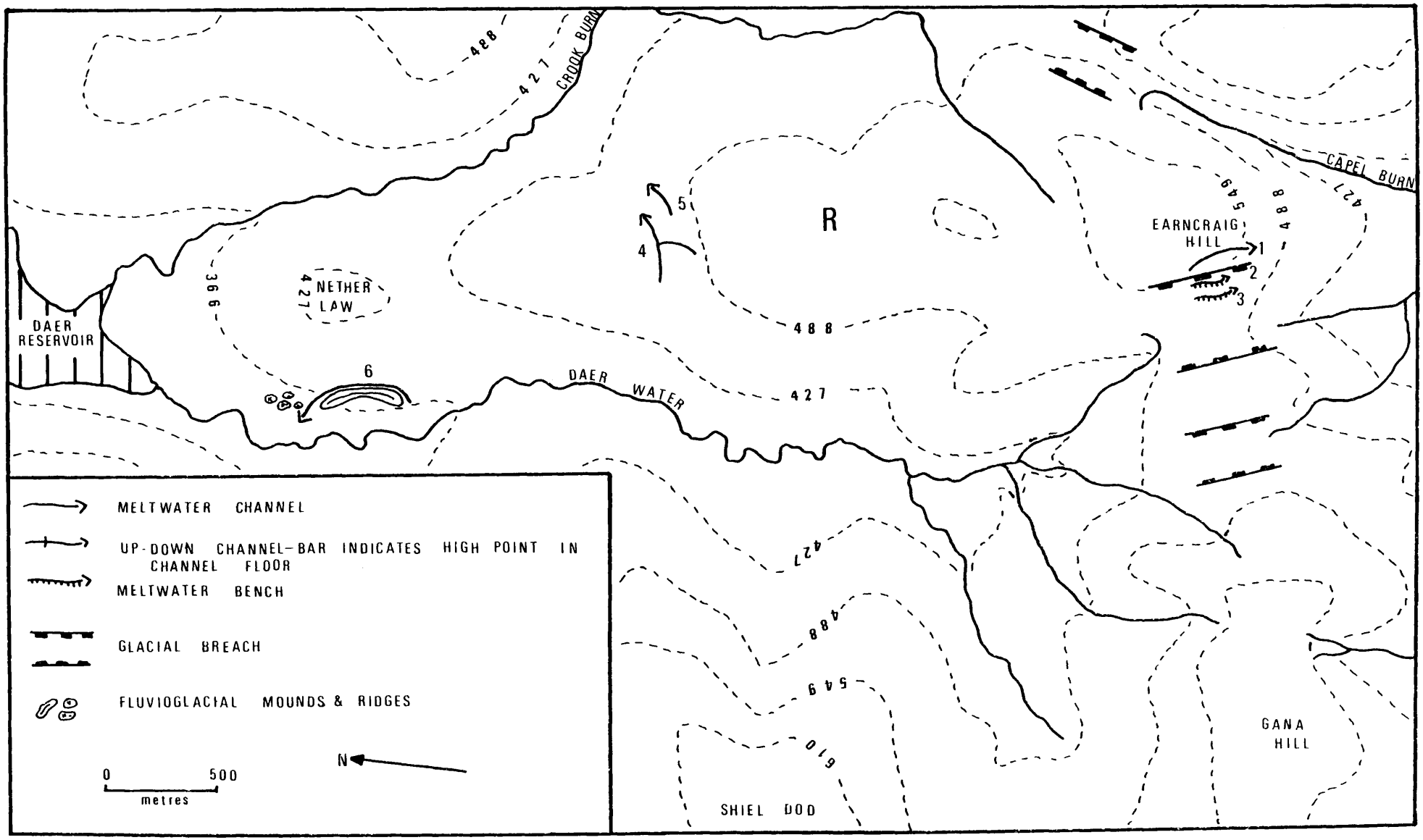


Fig. 4.22. Channel system R.

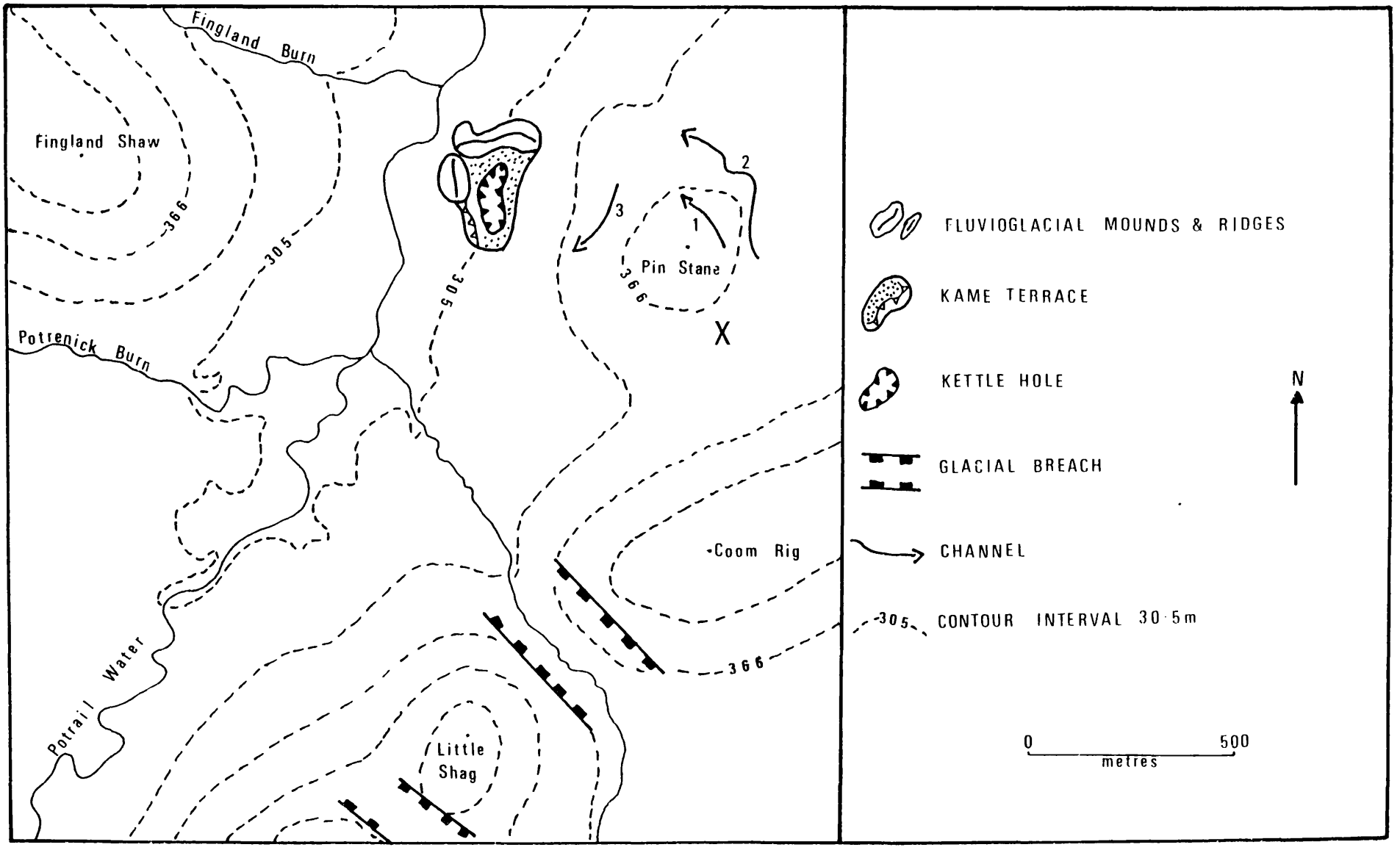


Fig. 4.23. Channel system X.

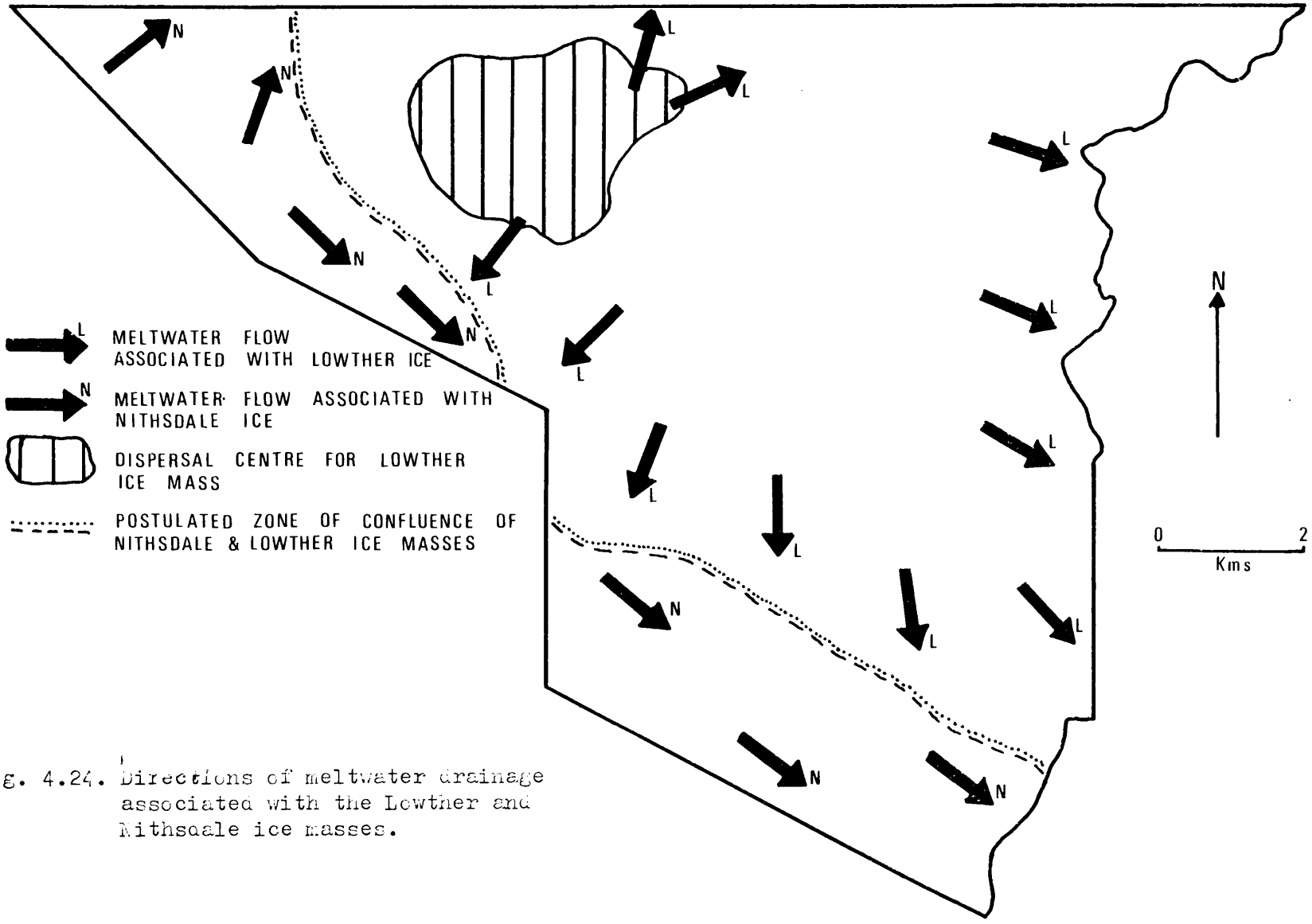


Fig. 4.24. Directions of meltwater drainage associated with the Lowther and Nithsdale ice masses.

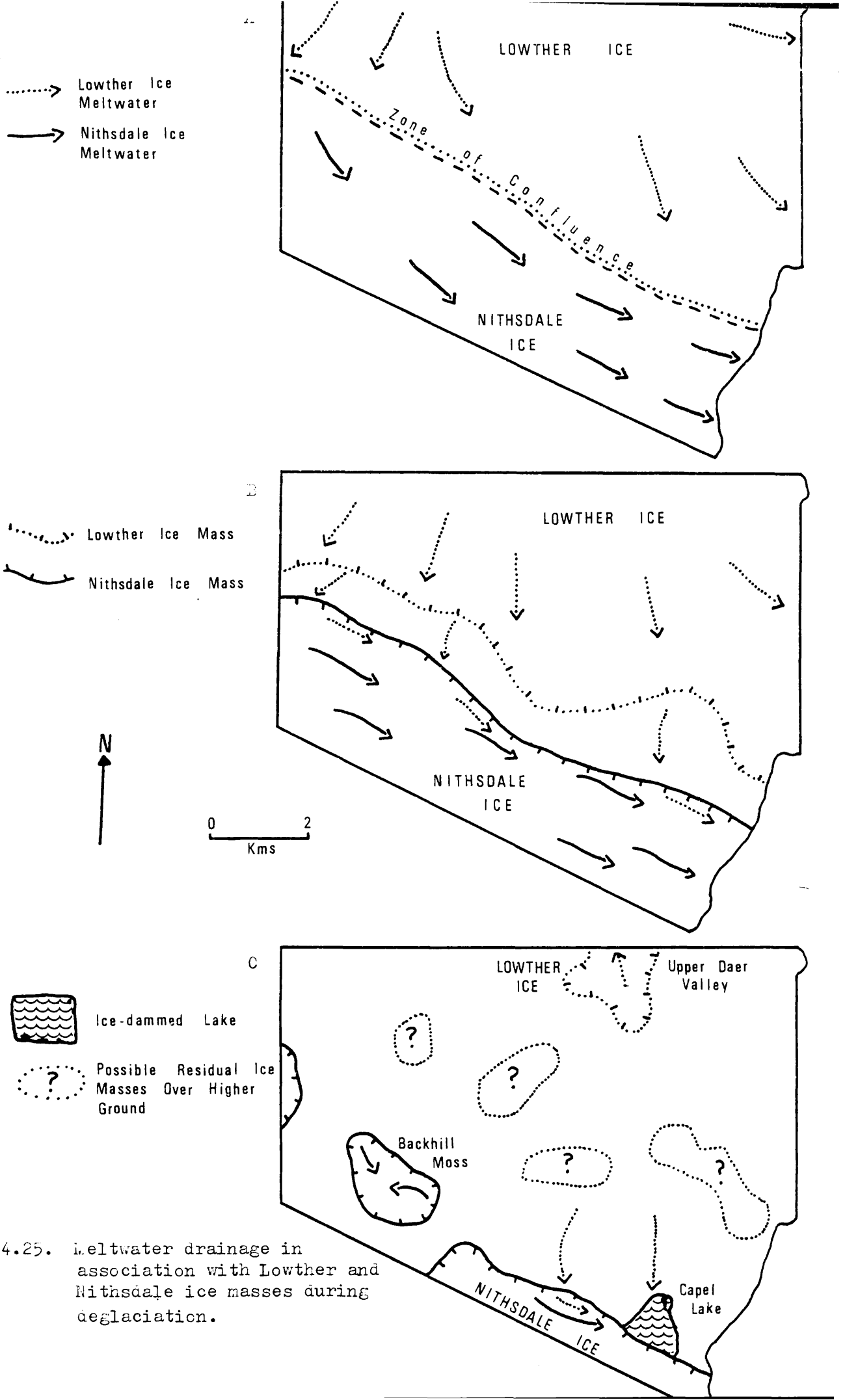


Fig. 4.25. Meltwater drainage in association with Lowther and Nithsdale ice masses during deglaciation.

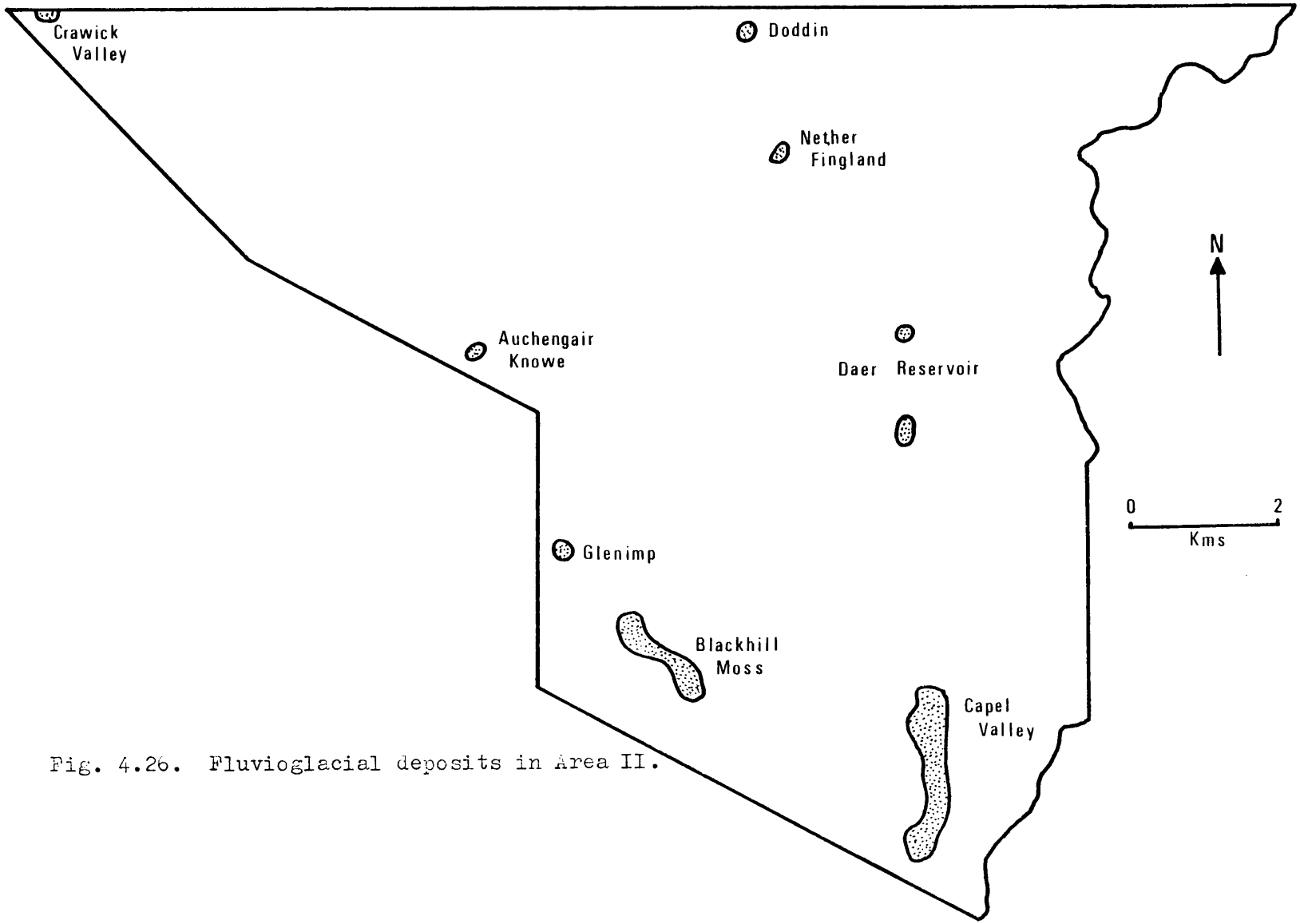


Fig. 4.26. Fluvioglacial deposits in Area II.

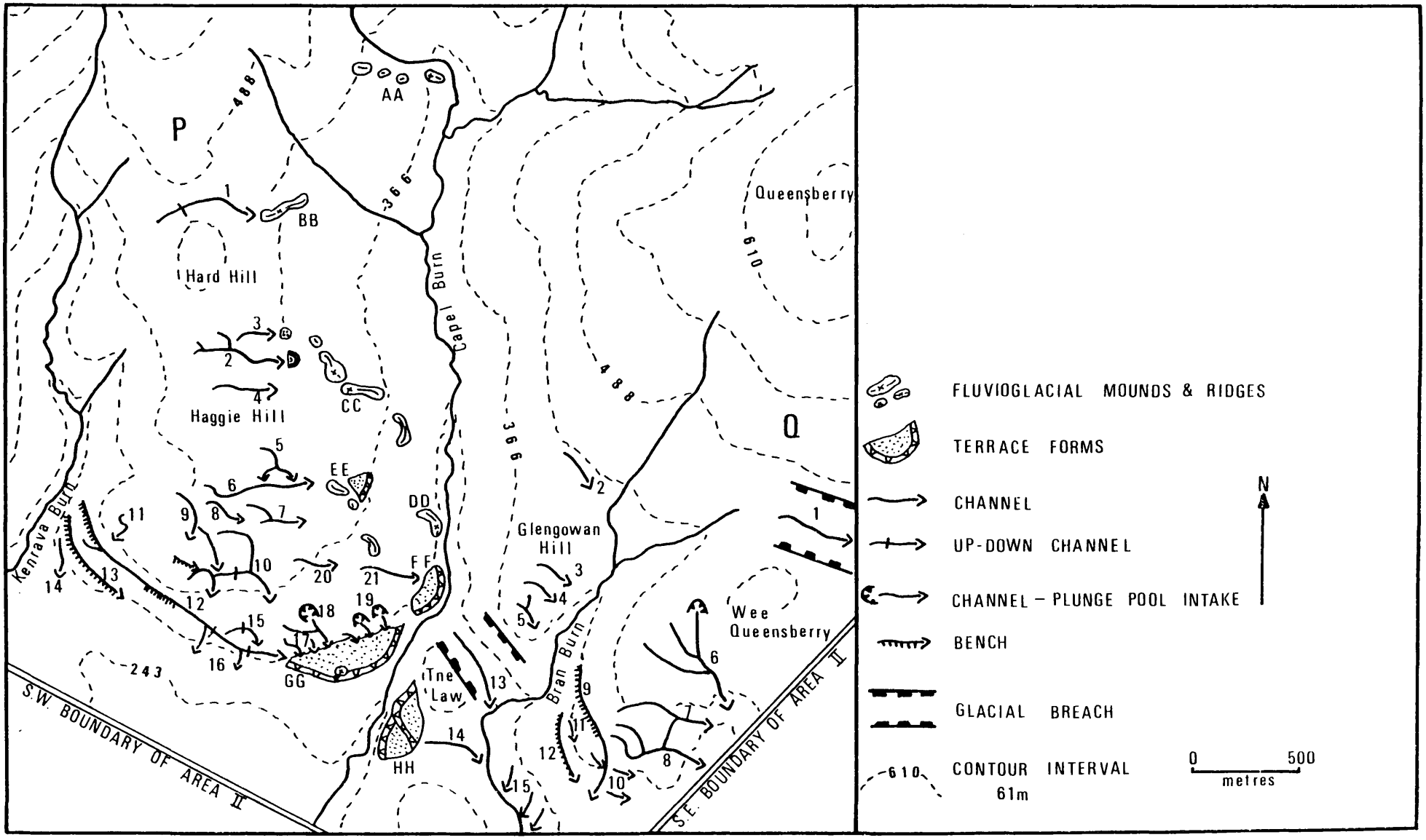


Fig. 4.27. Fluvioglacial landforms in the Capel valley.

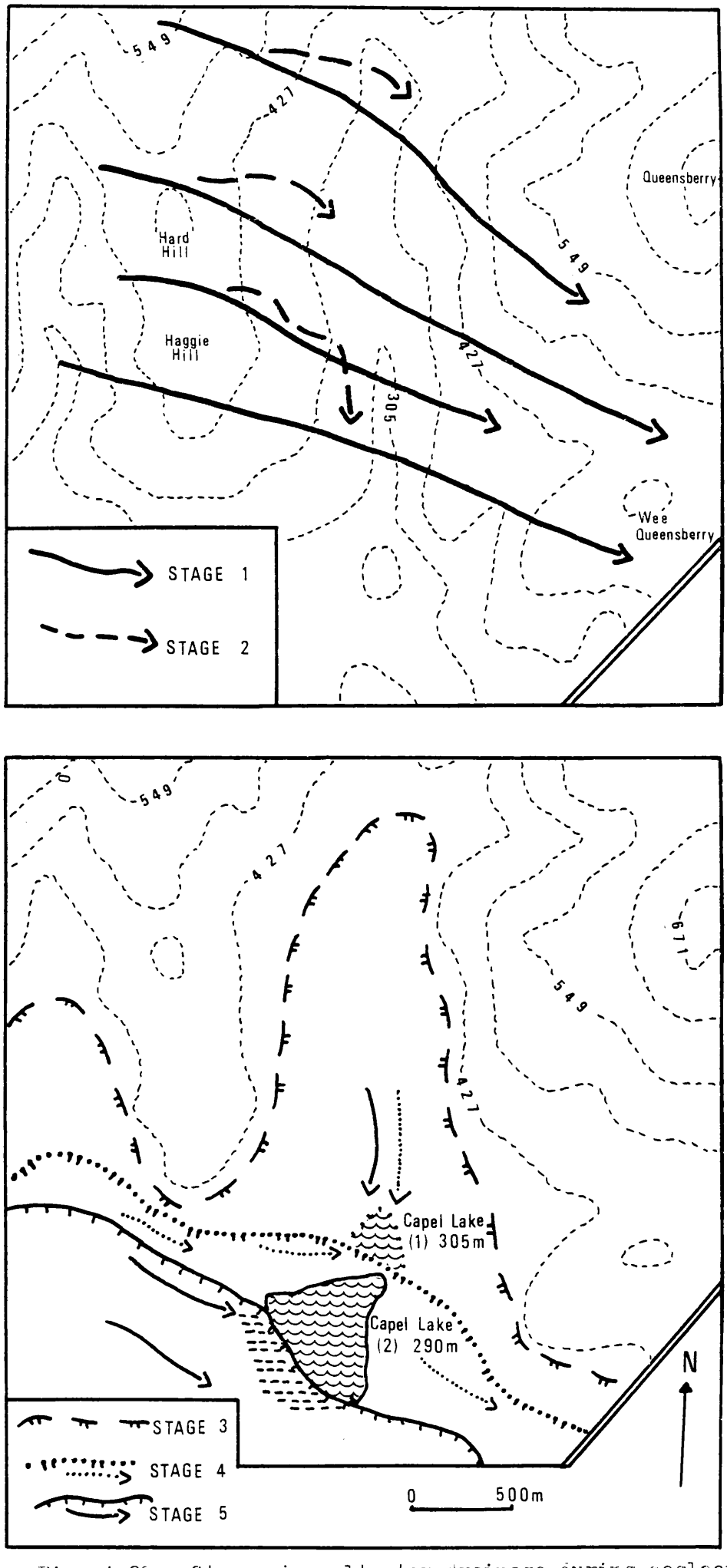


Fig. 4.28. Stages in meltwater drainage during deglaciation over the Capel Water valley.

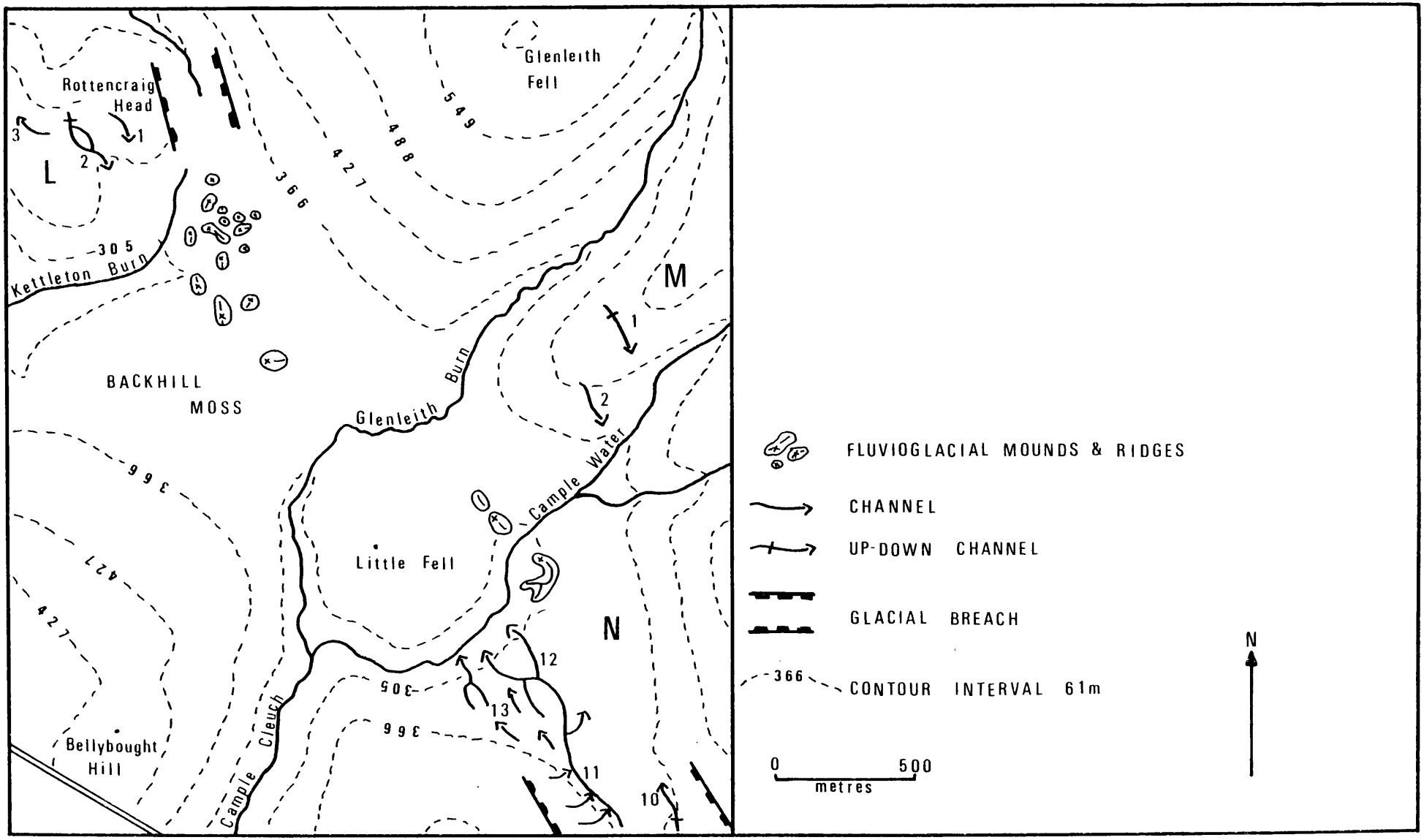


Fig. 4.29. Fluvioglacial landforms in the vicinity of Backhill Moss.

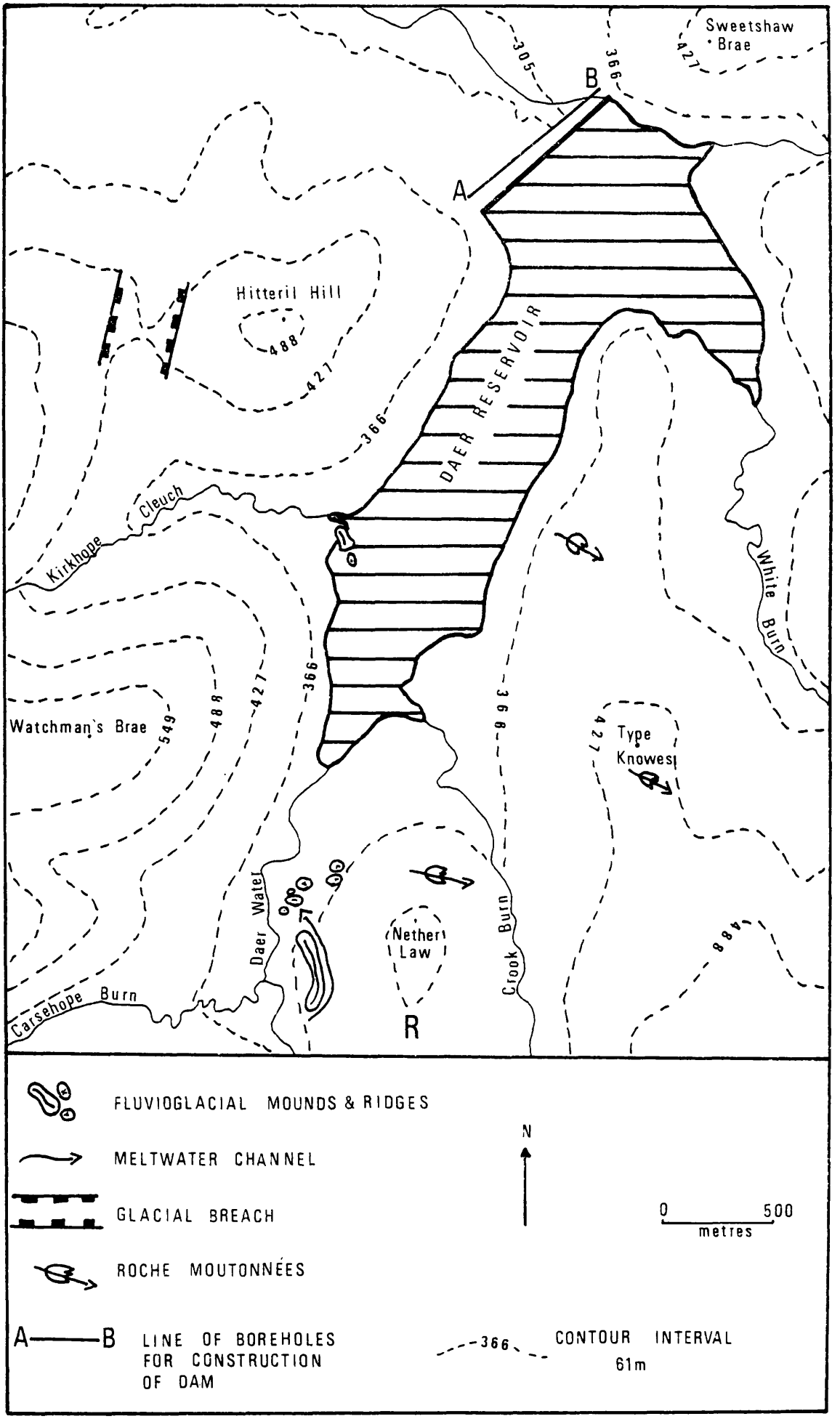


Fig. 4.30. Fluvioglacial landforms in the vicinity of the Daer Reservoir.

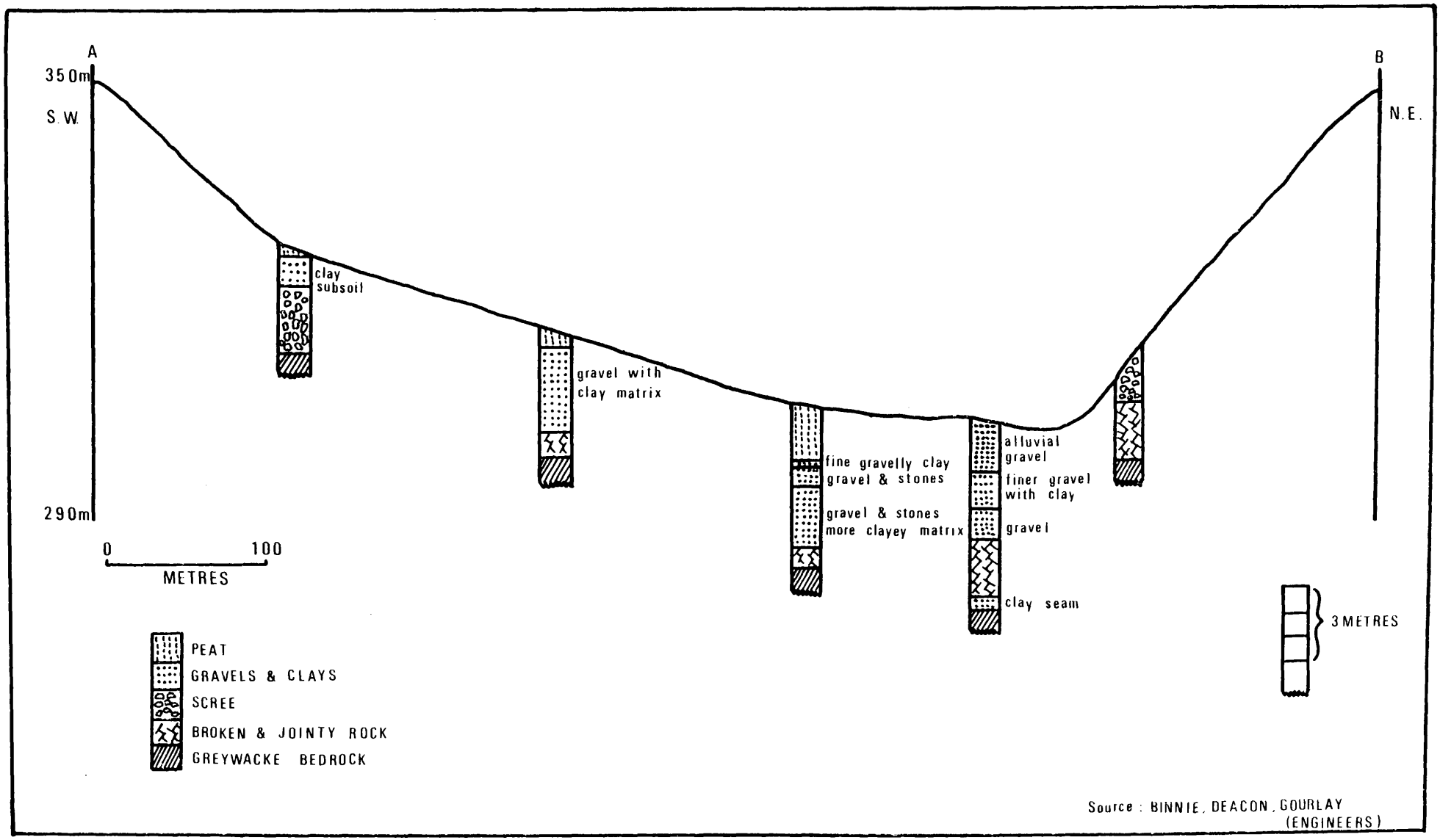


Fig. 4.31. Drift thicknesses from borehole evidence at the Daer Reservoir.

MAPS AND DIAGRAMS - CHAPTER 5.

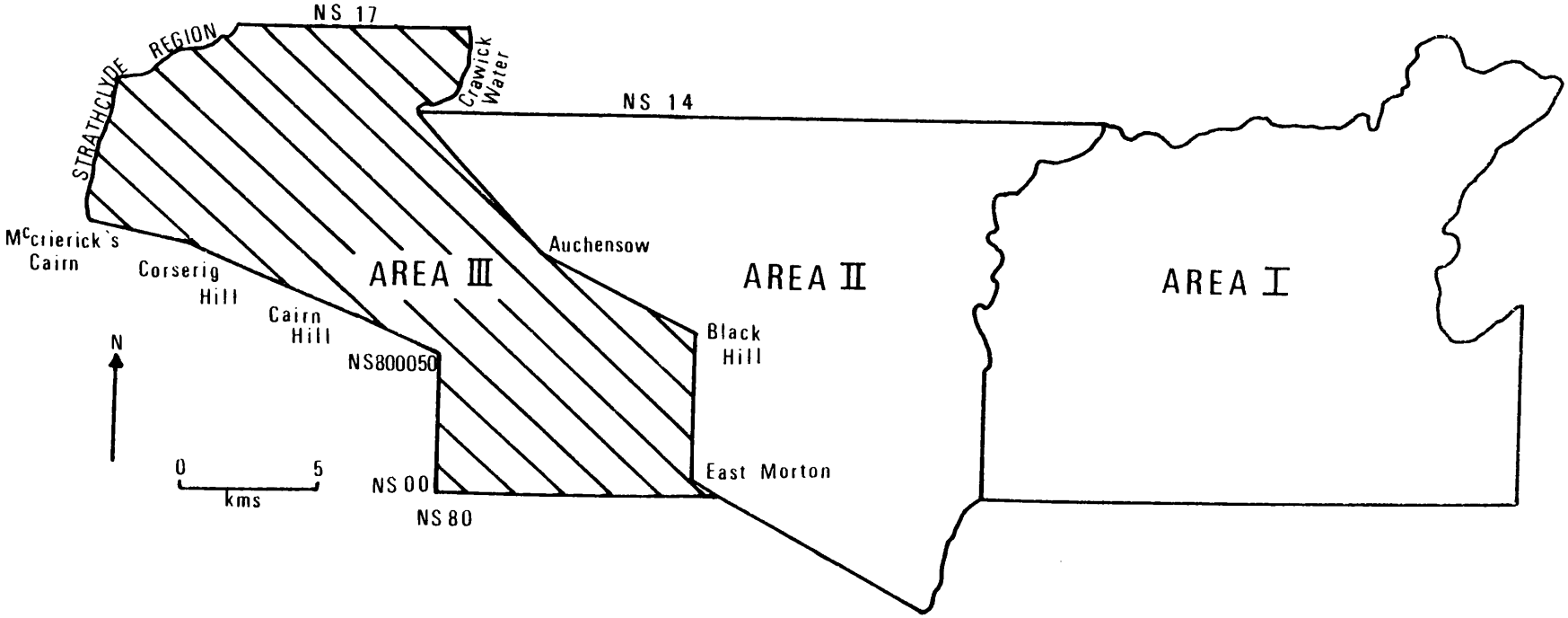

NS 17
REGION
STRATHCLYDE
Crawick Water
NS 14
McCrierick's Cairn
Corserig Hill
Cairn Hill
AREA III
AREA II
AREA I
Auchensow
Black Hill
N
NS800050
0
5
kms
NS 00
NS 80
East Morton

Fig. 7.7. [illegible]

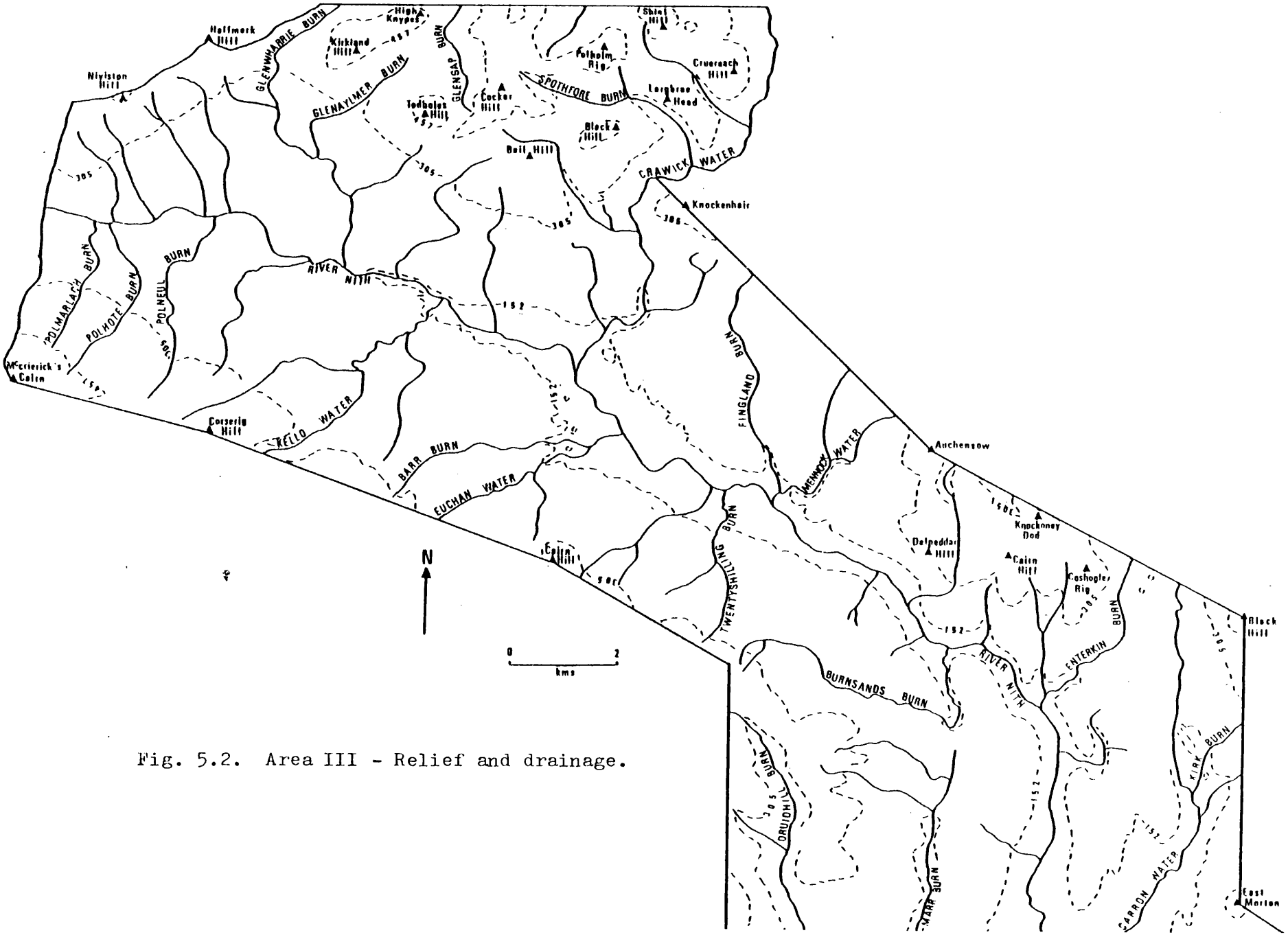
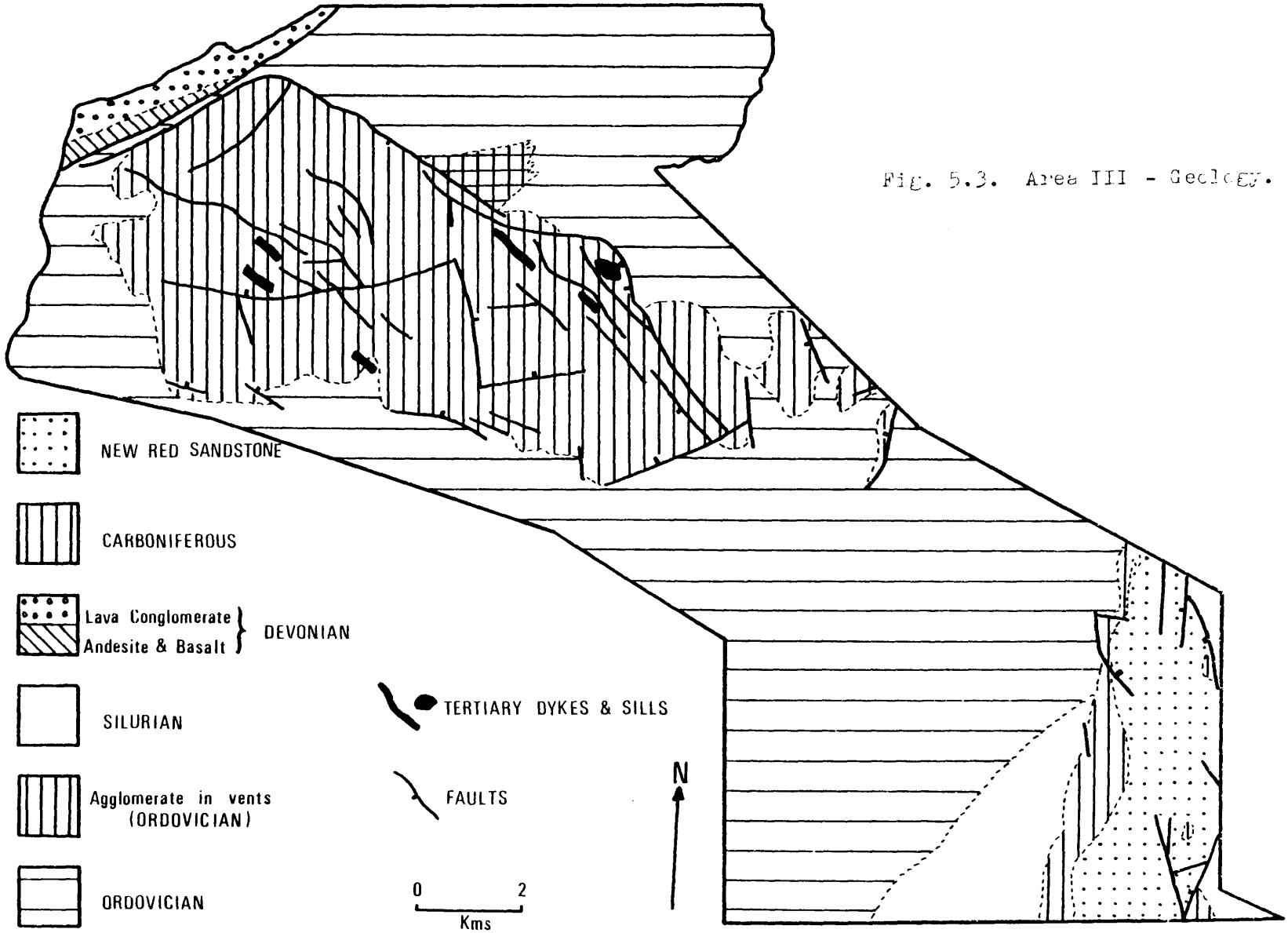


Fig. 5.2. Area III - Relief and drainage.

Fig. 5.3. Area III - Geology.



Source: GEOLOGICAL SURVEY

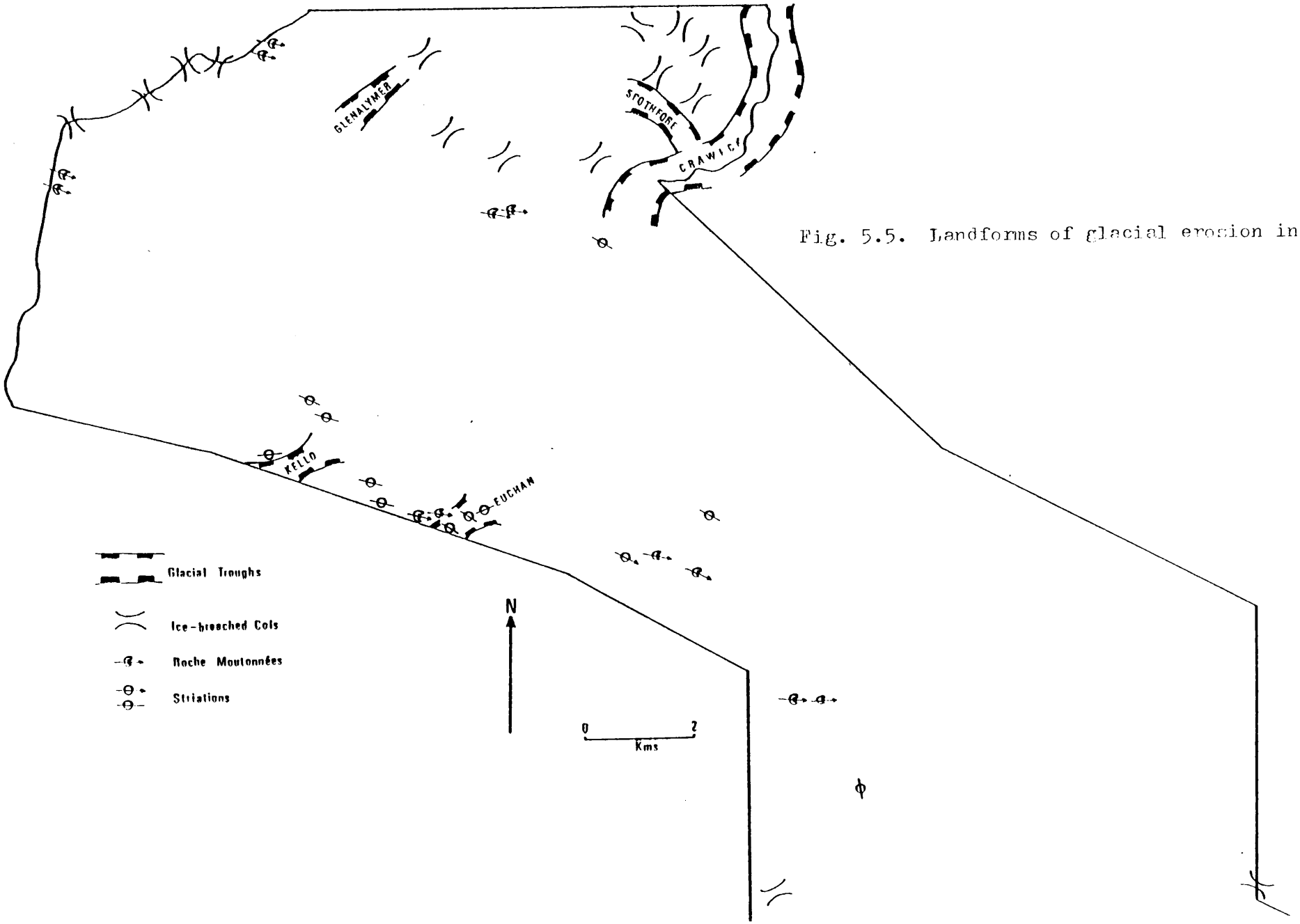


Fig. 5.5. Landforms of glacial erosion in Area III

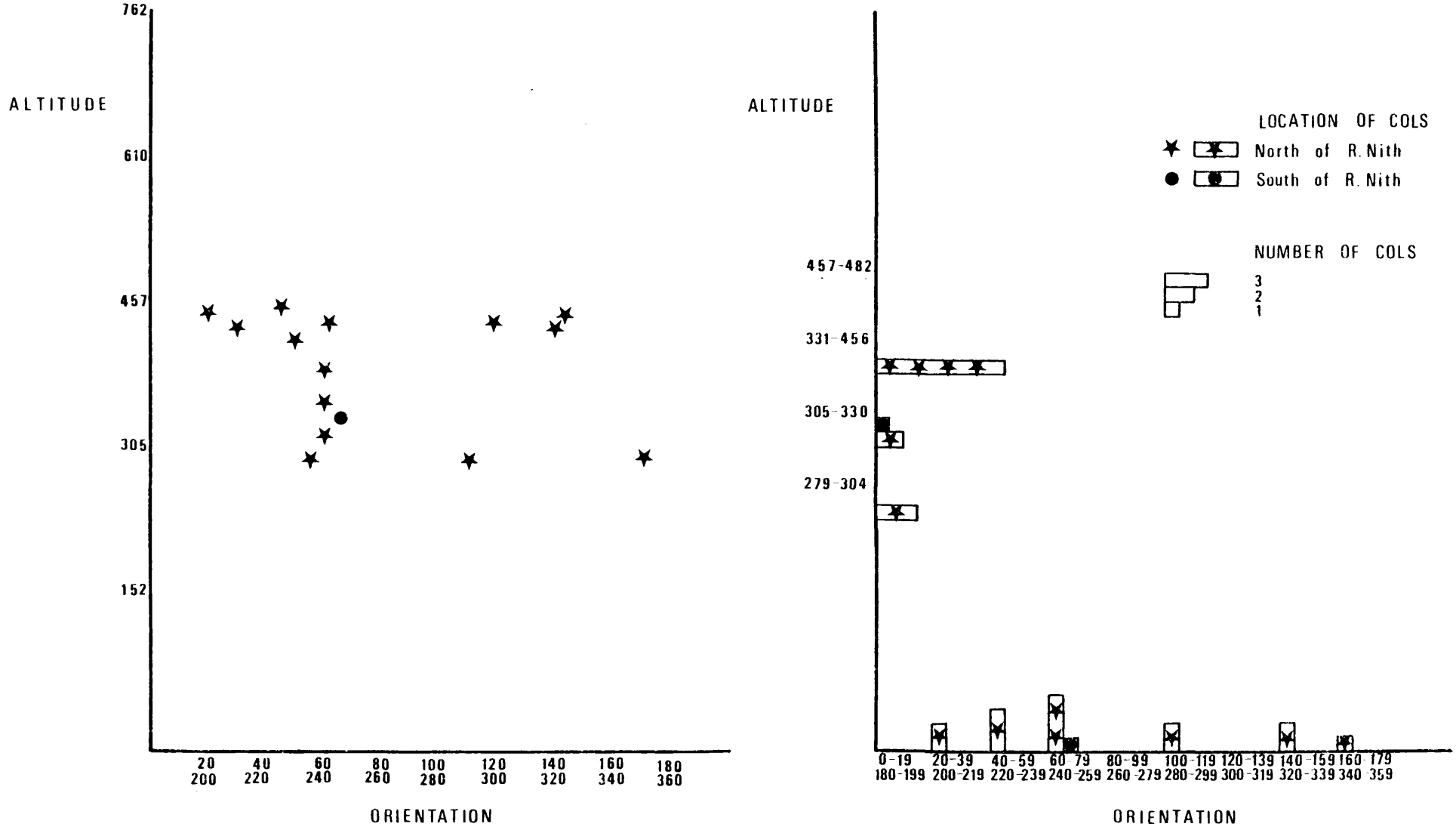


Fig. 5.o. Area III - Altitude and alignment of cols.

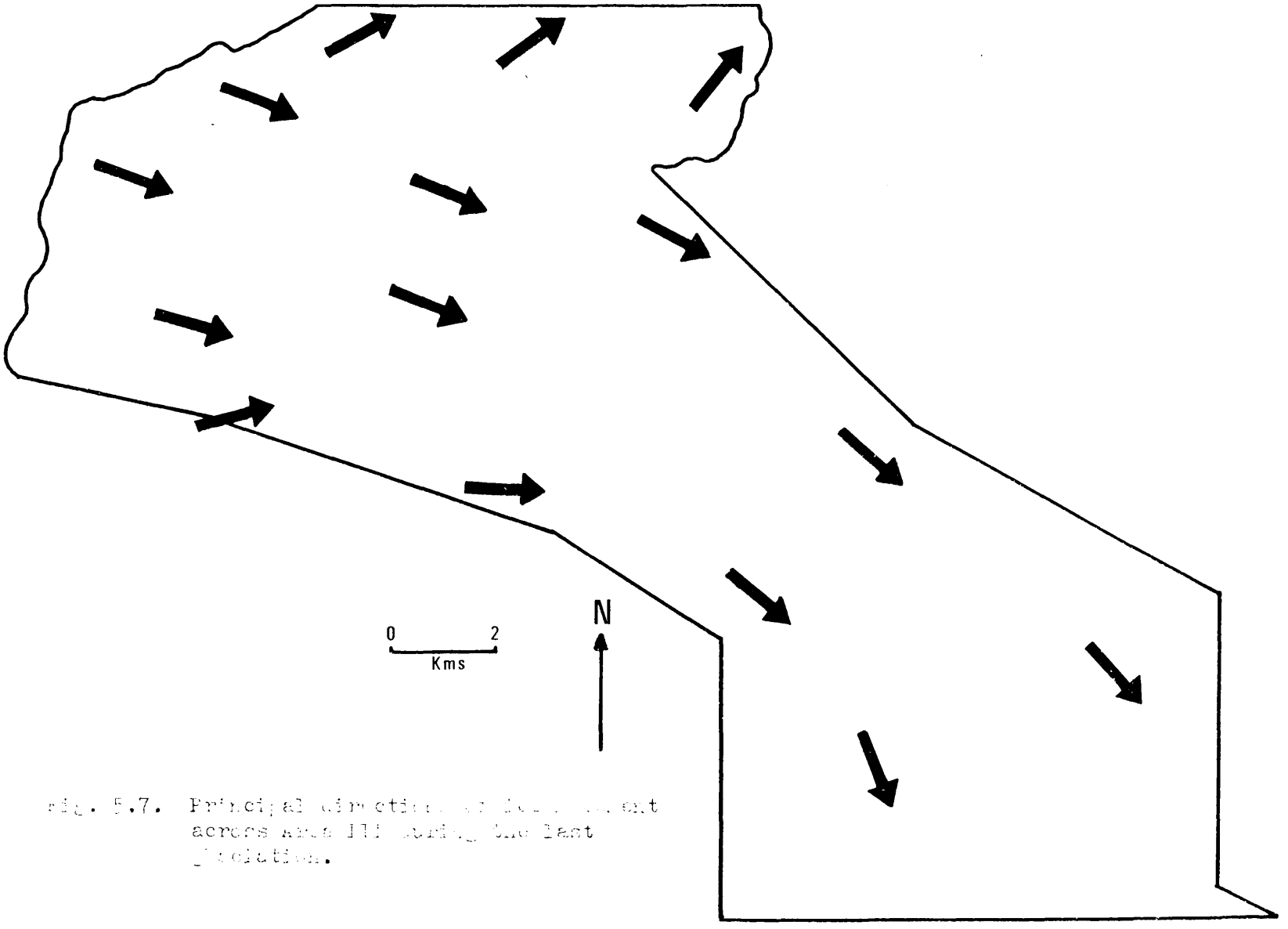


Fig. 5.7. Principal direction of [illegible] across area III during the last [illegible]

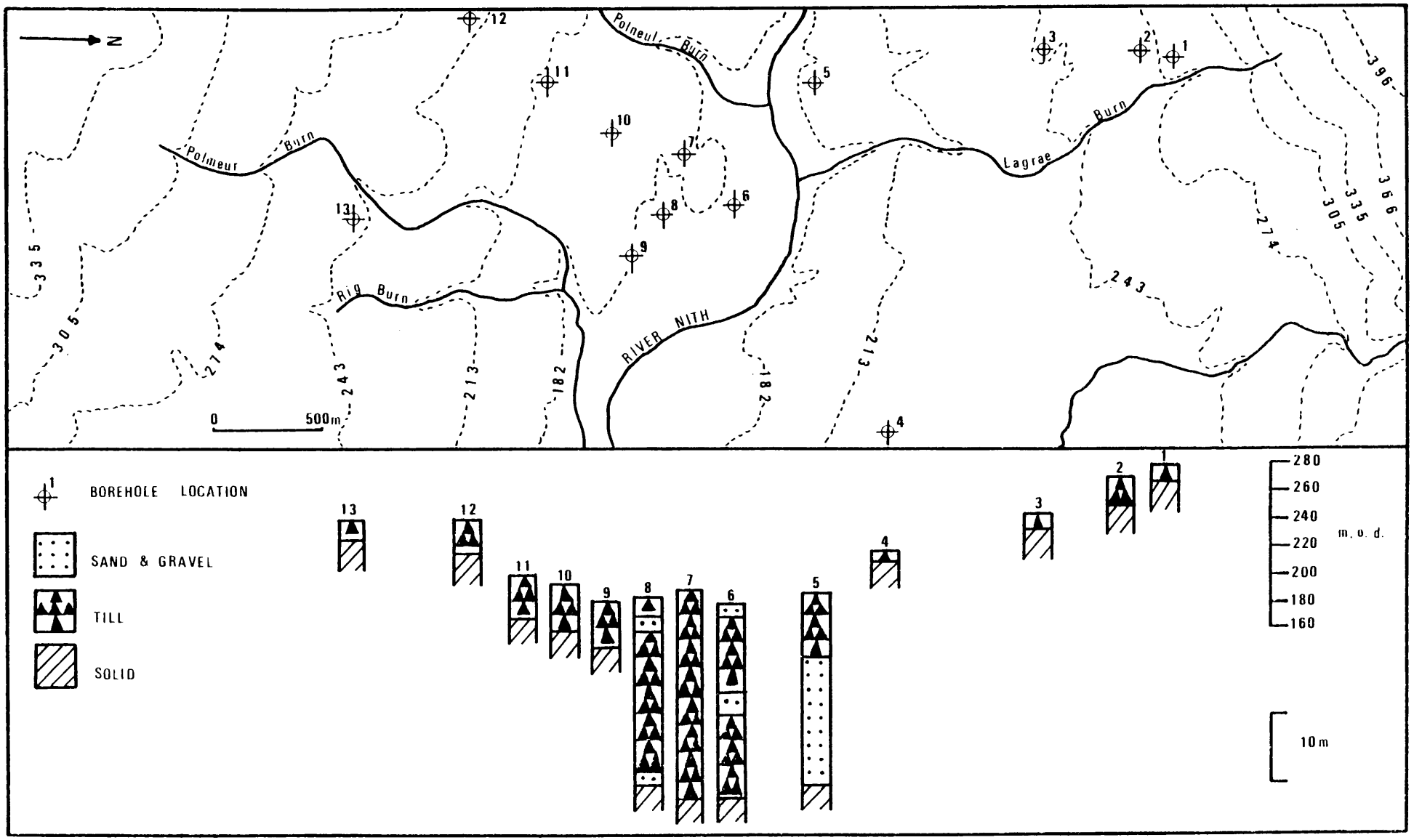


Fig. 5.8. Drift thickness in Nithsdale, as indicated from borehole records

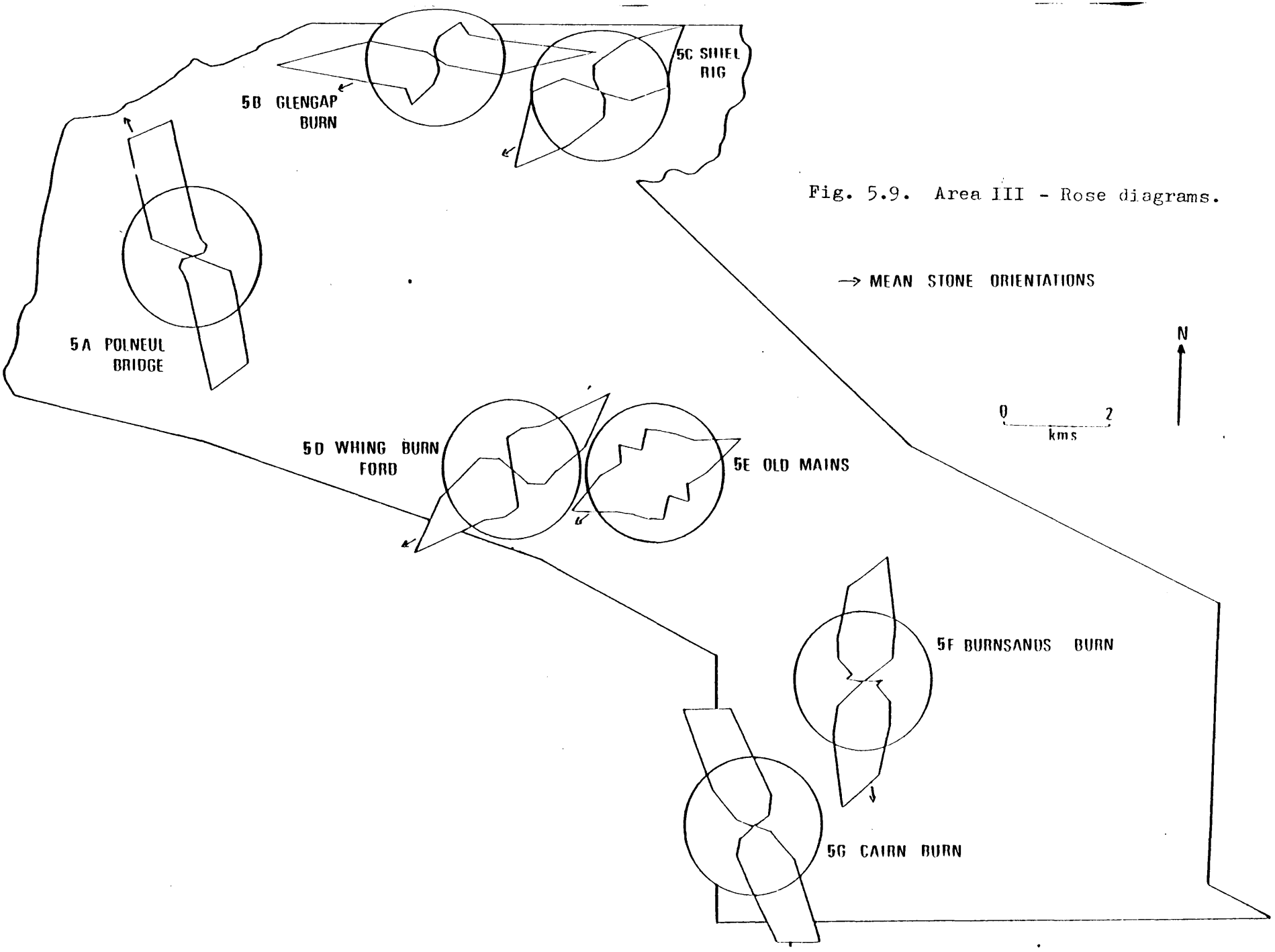


Fig. 5.9. Area III - Rose diagrams.

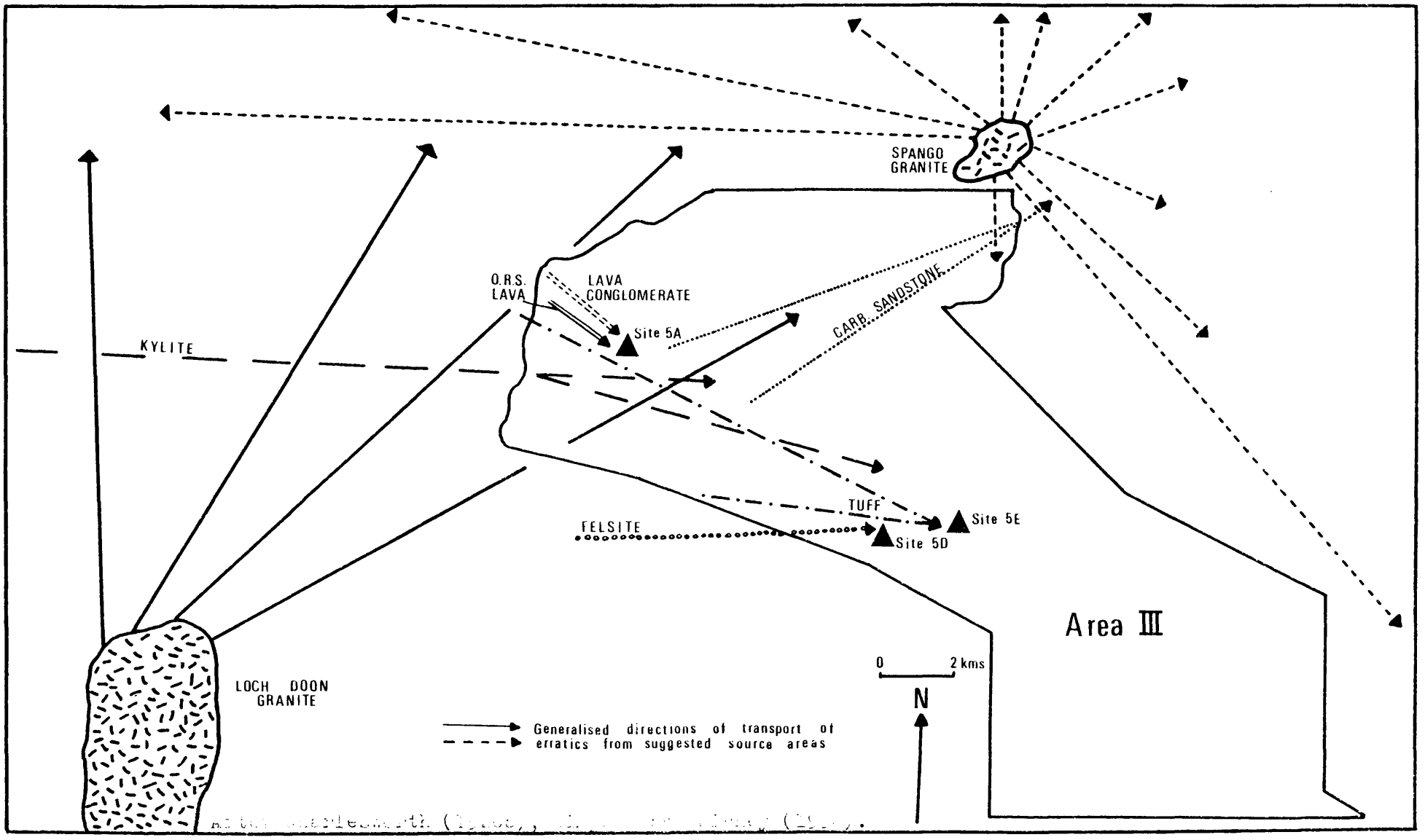
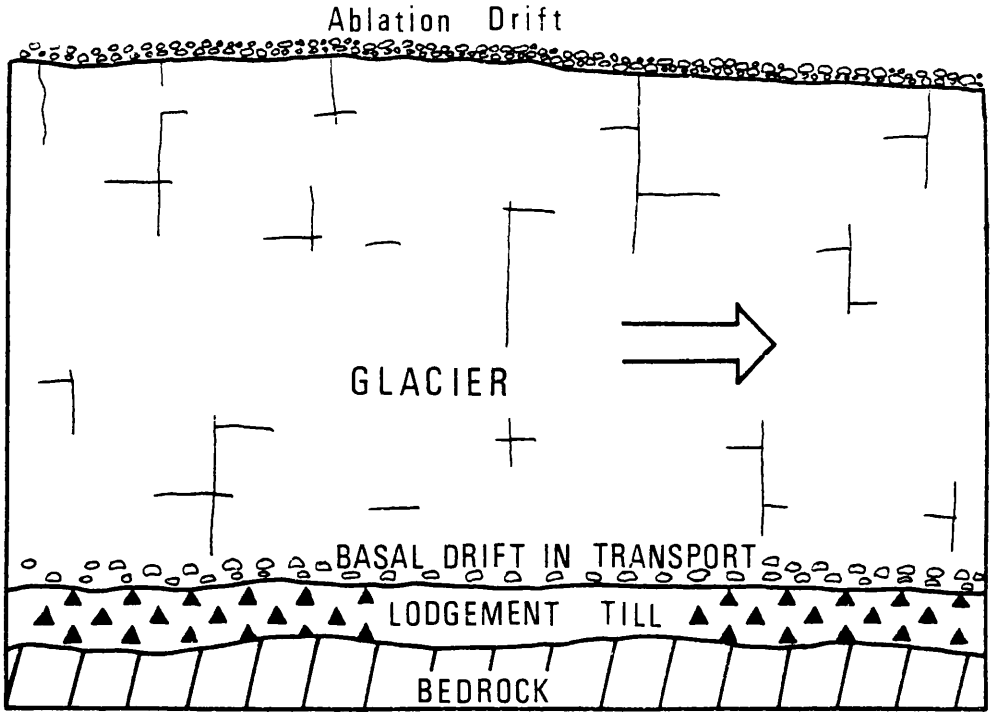
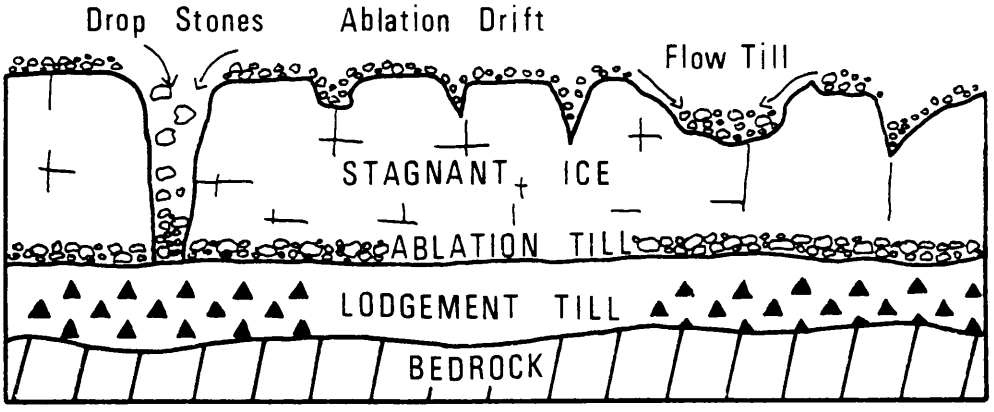
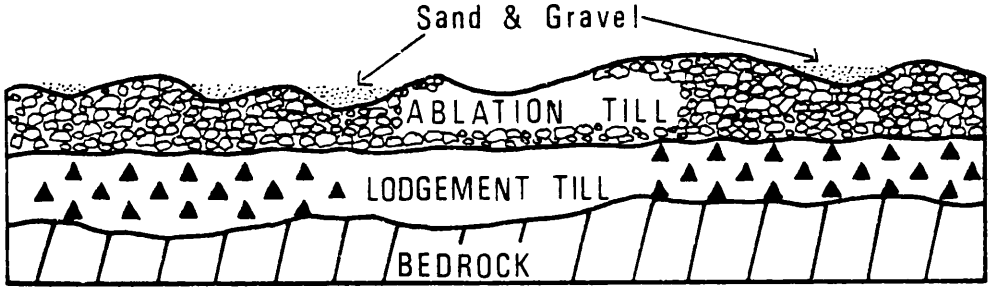


Fig. 5.1C. Erratic transport in the vicinity of Area III.







(Adapted from Flint, 1971, P173)

Fig. 5.11. [illegible] ablation till.

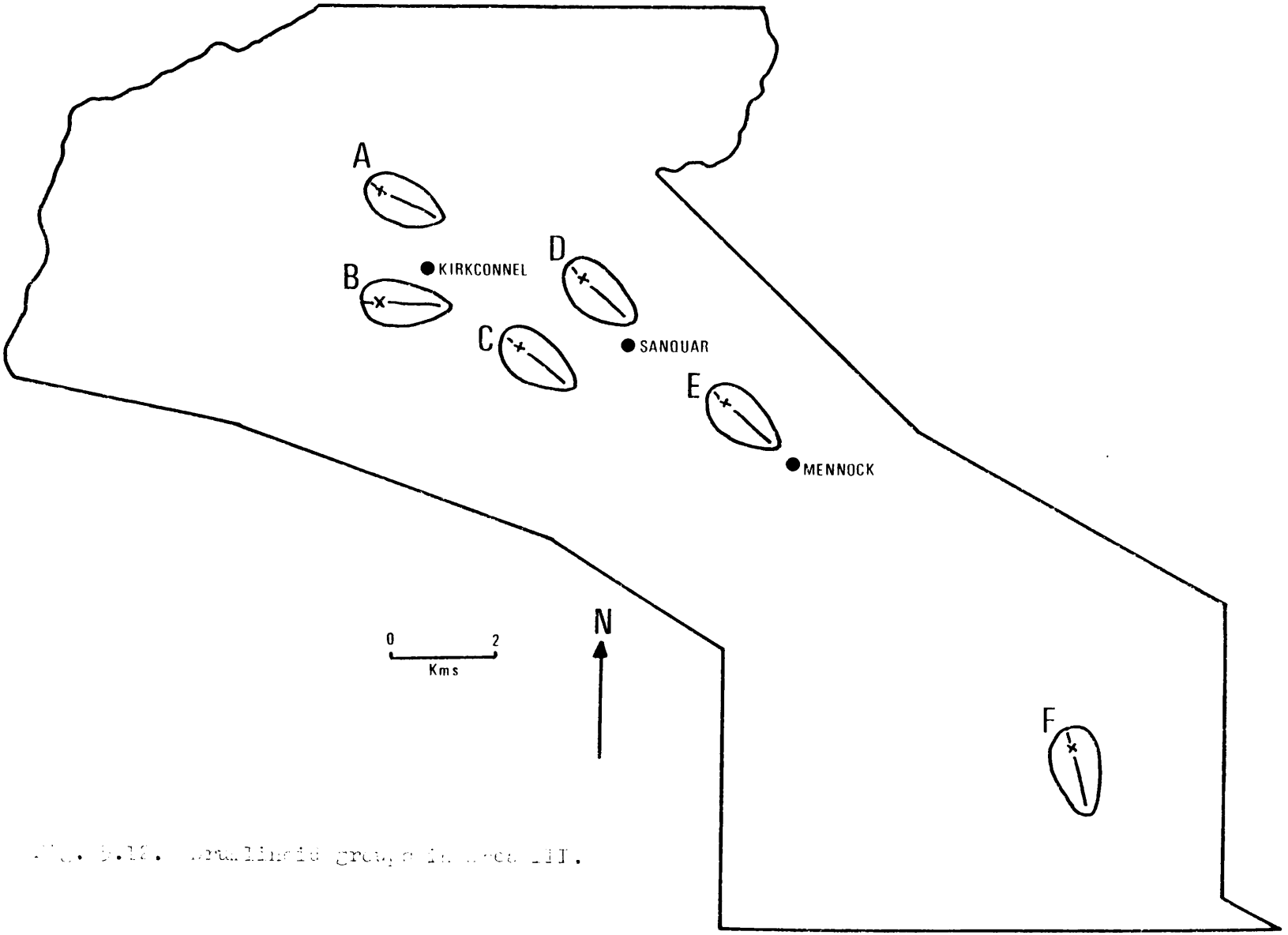


Fig. 5.16. Drumlinoid groups in area III.

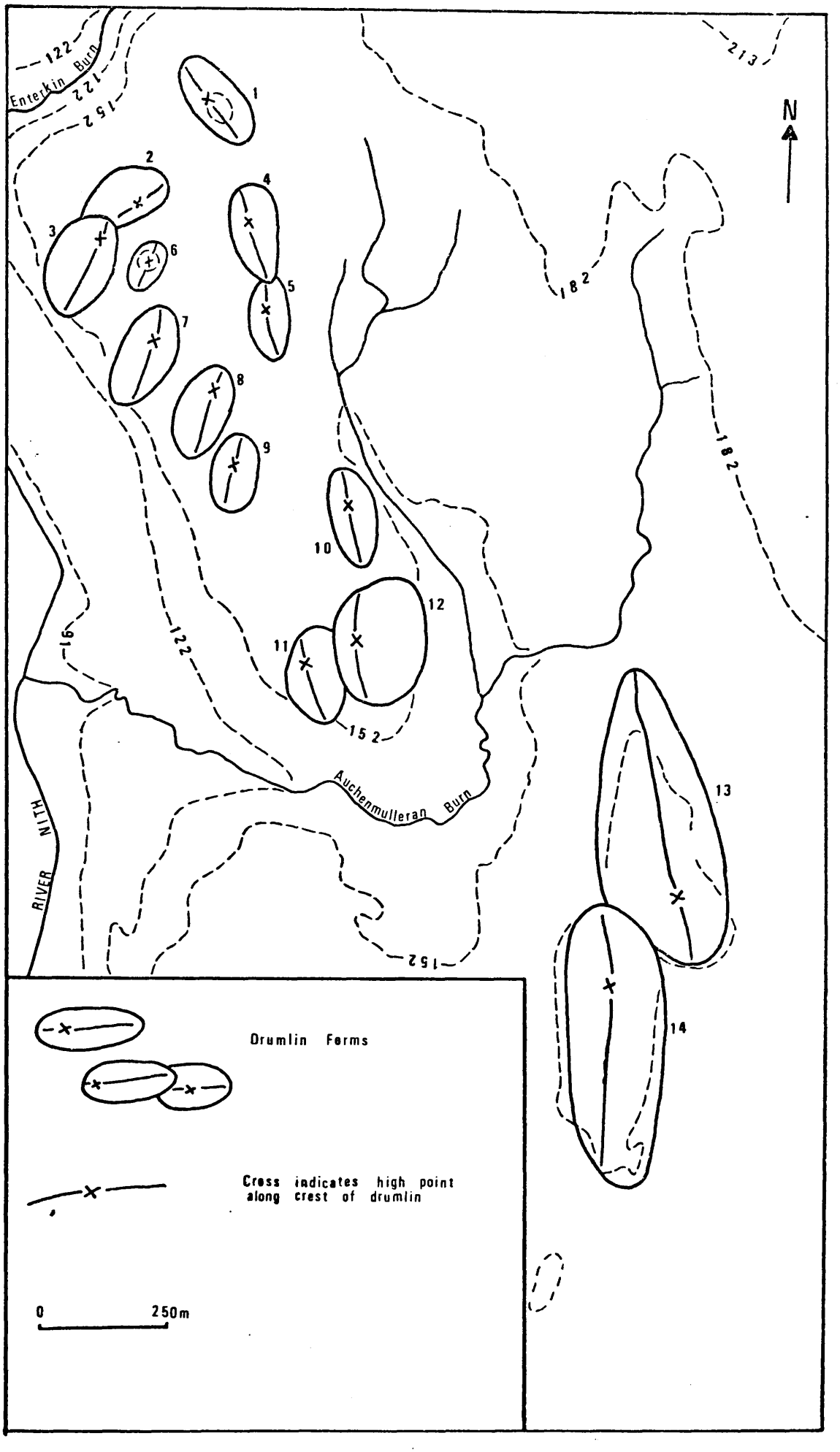


Fig. 5.13. Drumlin group F.

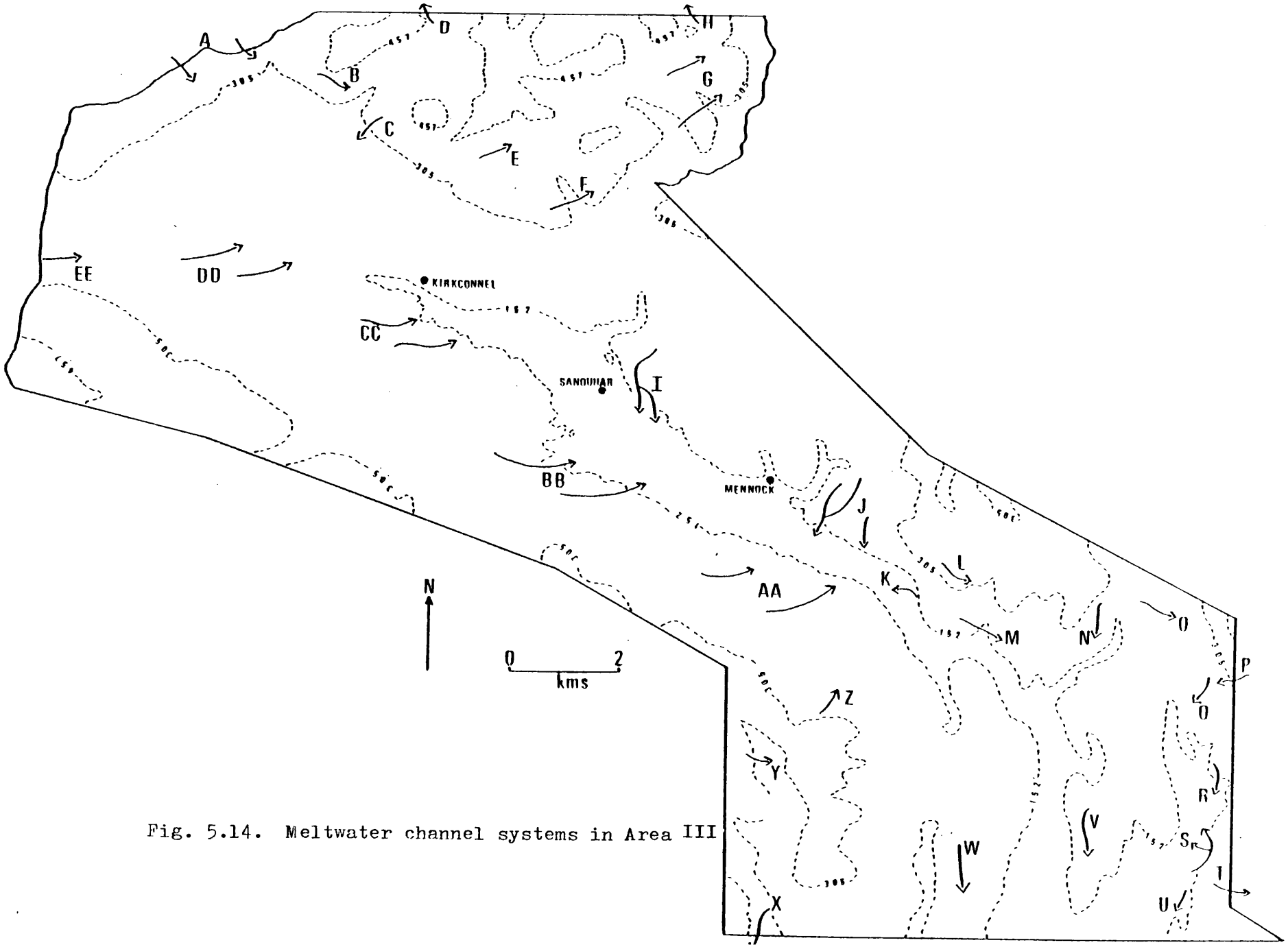


Fig. 5.14. Meltwater channel systems in Area III

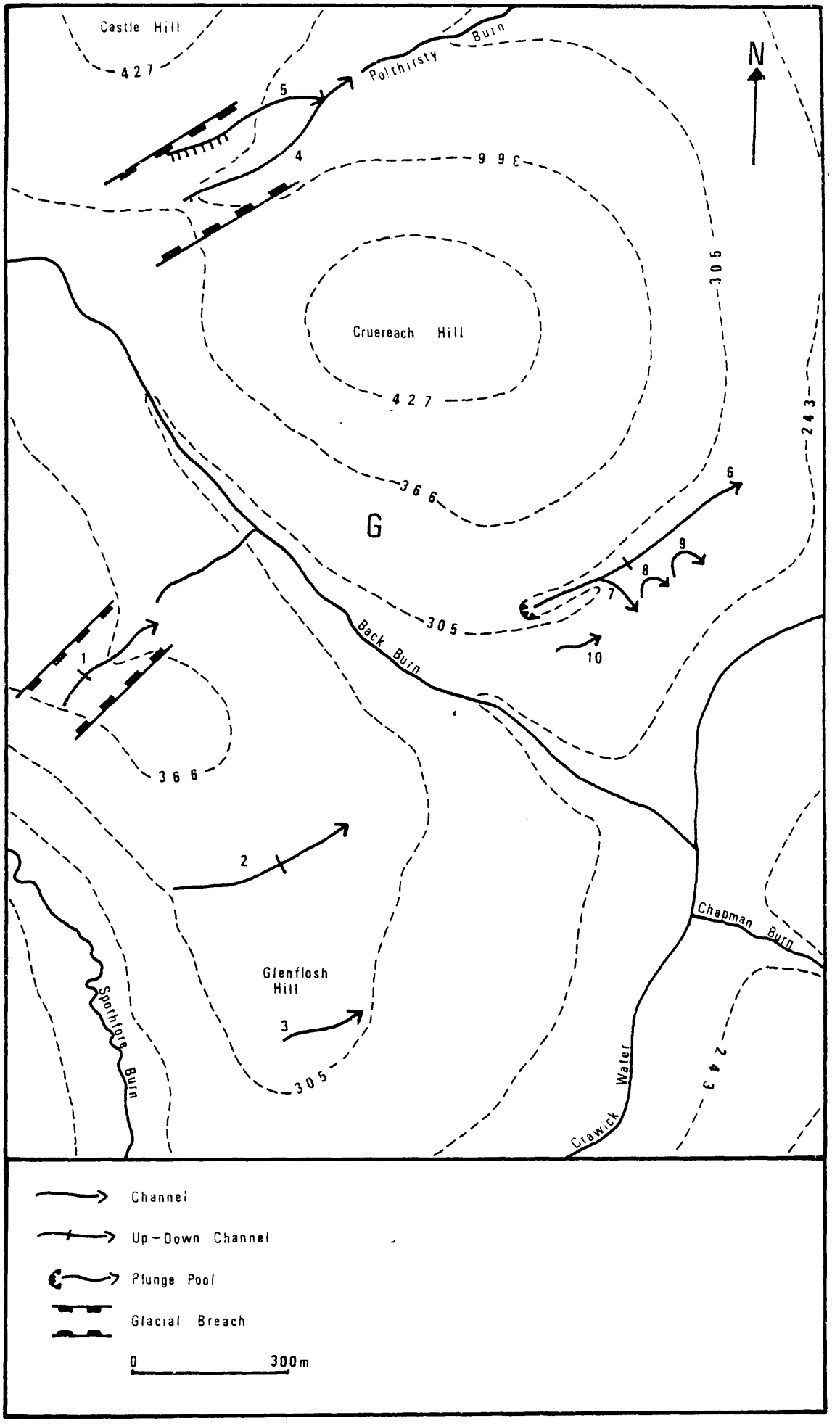
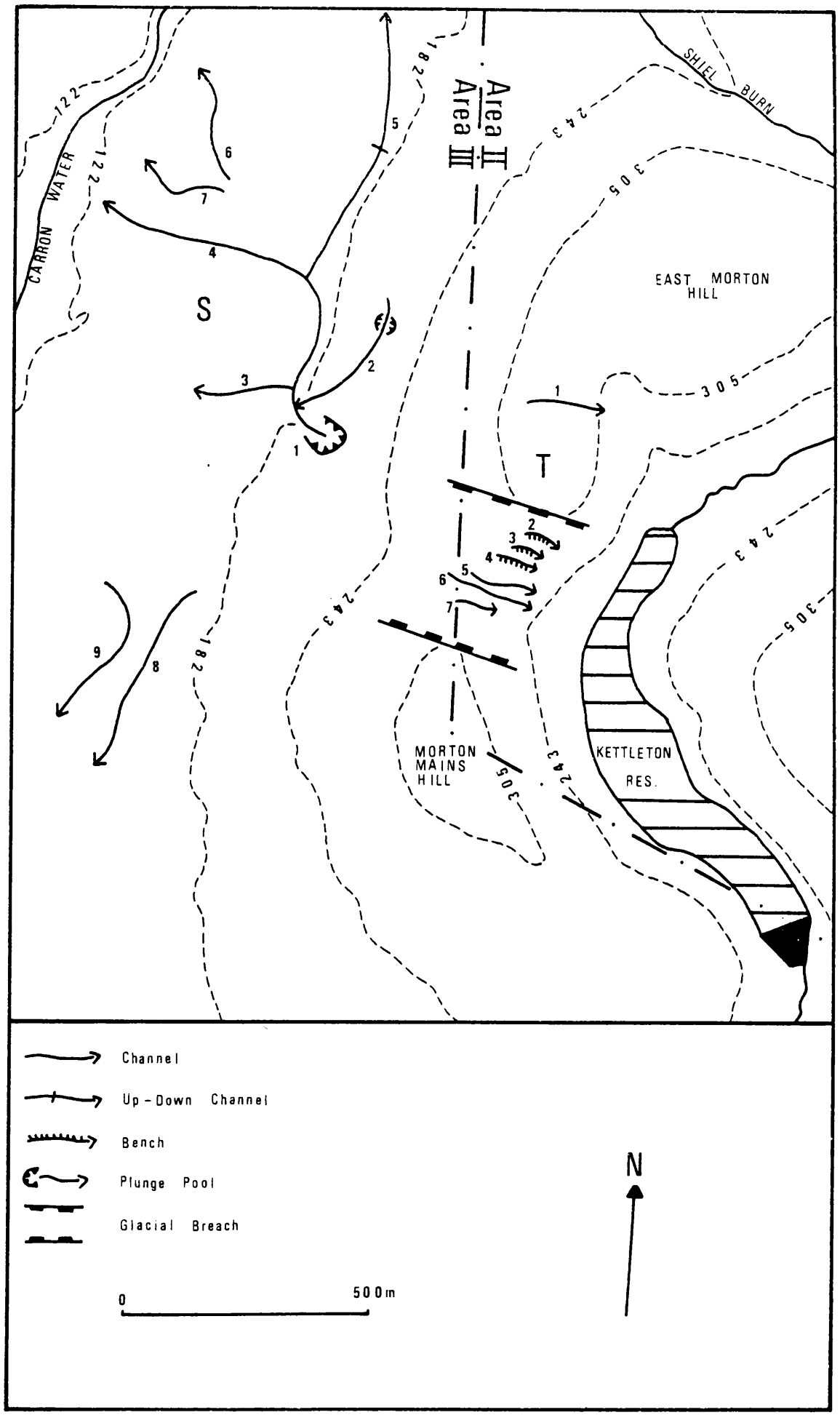


Fig. 5.15. Channel system G.


Area II
Area III
CARRON WATER
SHIEL BURN
EAST MORTON HILL
MORTON MAINS HILL
KETTLETON RES.
S
T
122
182
243
305
Channel
Up - Down Channel
Bench
Plunge Pool
Glacial Breach
0
500m
N

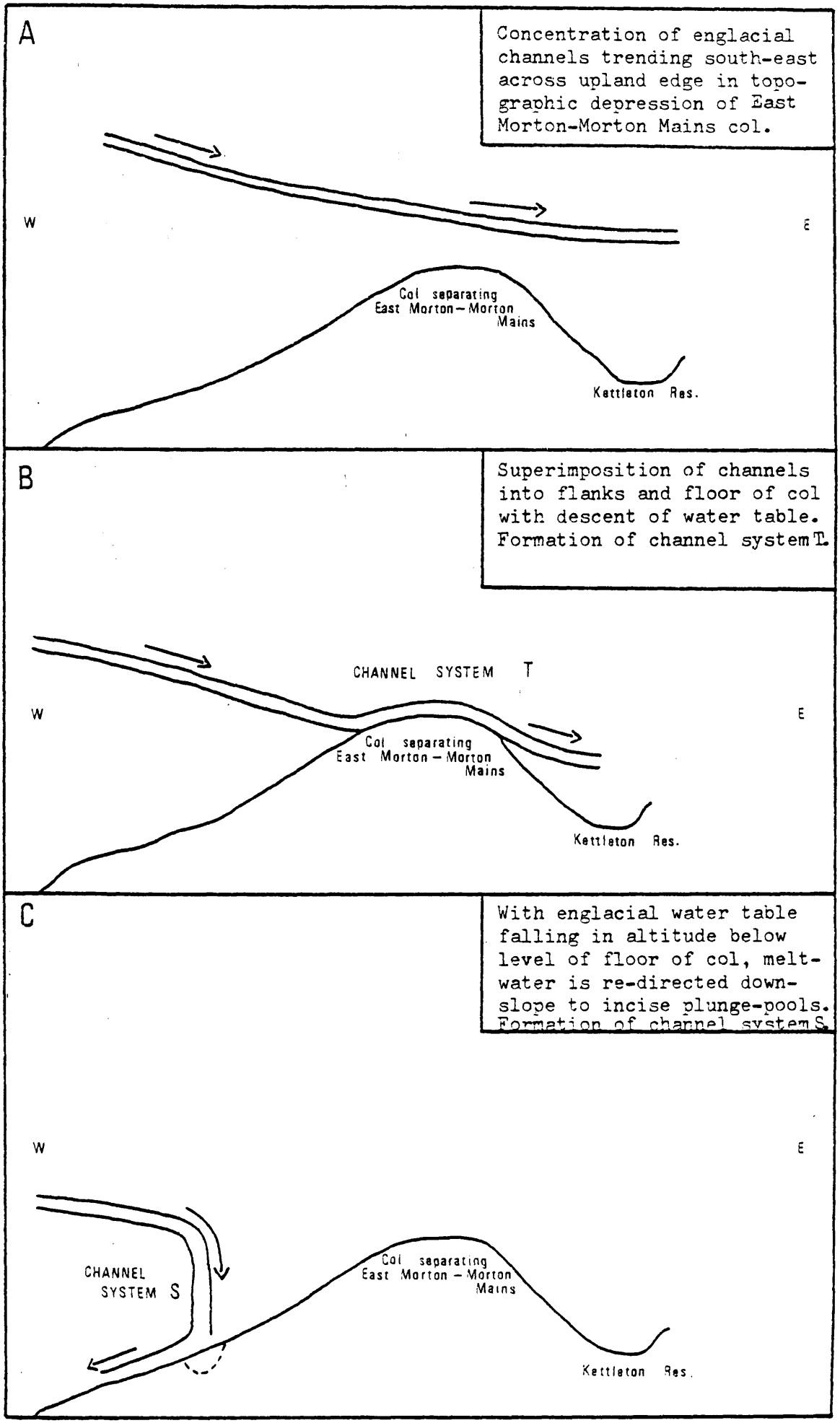


Fig. 5.17. Formation of channel systems S and T.

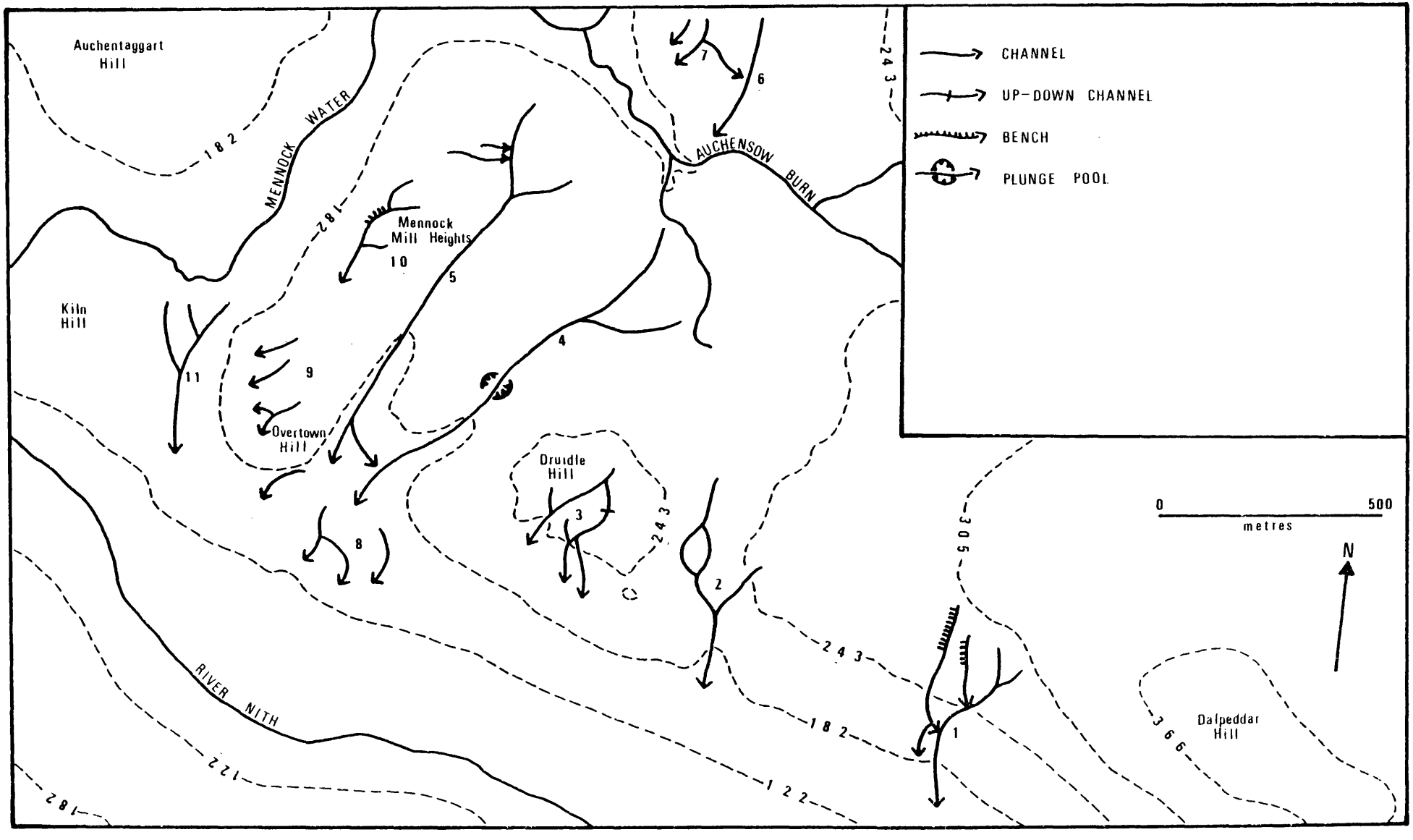


Fig. 5.18. Channel system J.

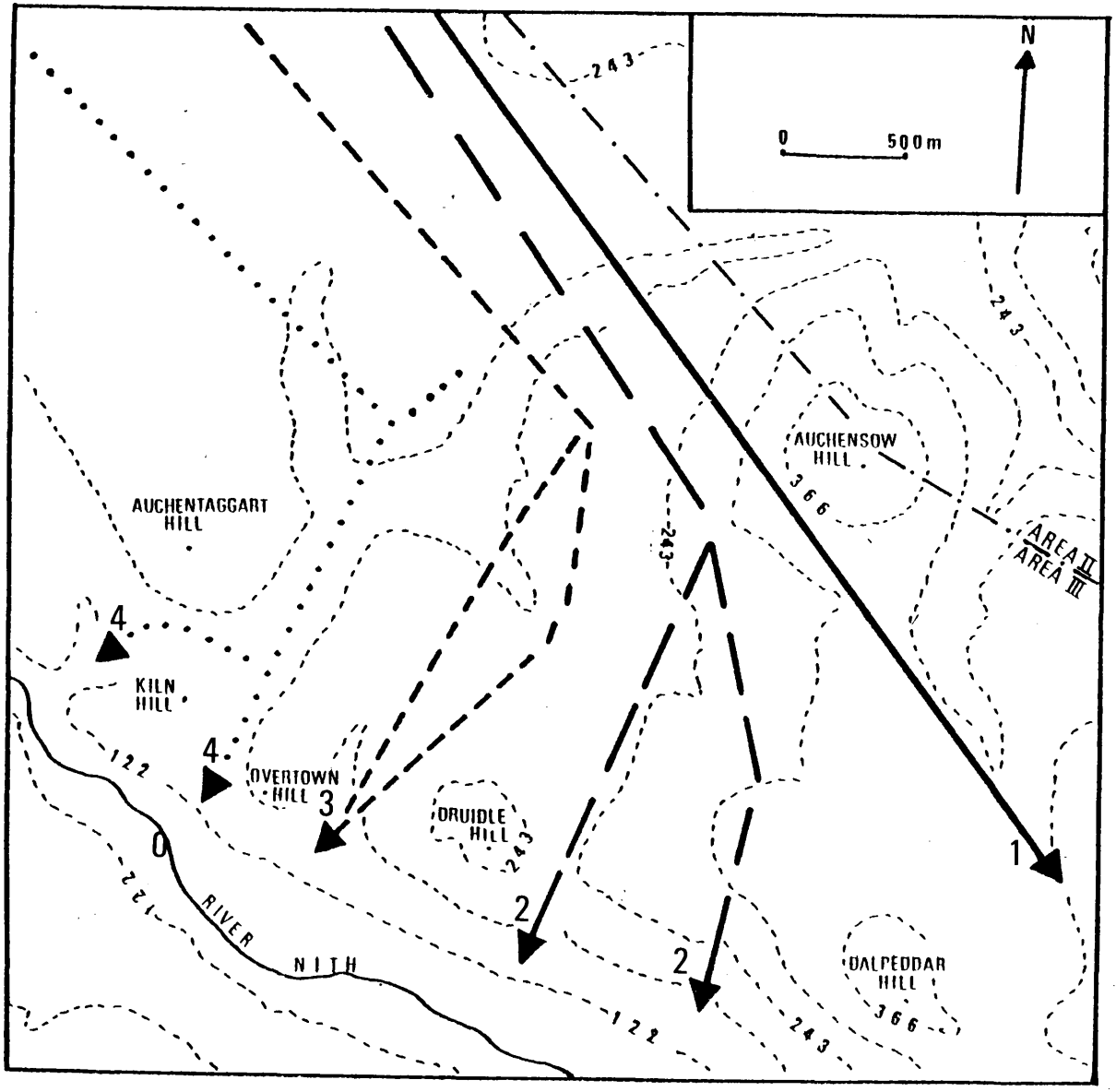


Fig. 5.19. Formation of channel system J.

STAGE 1 Original south-east movement of meltwater down Nithsdale, ie. above 300m.

STAGE 2 With downwastage, Auchensow-Dalpeddar ridge became an upland barrier to south-east meltwater drainage Meltwater re-directed southwards to the Nith Valley. Initial erosion carried out by a series of independent streams down to 152 m.o.d..

STAGE 3 Continued downwastage results in the concentrat of meltwater in the low-lying area between Overtown Hill Druidle Hill. Both channels J^4 and J^5 probably carried meltwater simultaneously. J^4 is slightly the more deepl incised as a result of additional influx of meltwater fr englacial stream(s) descending abruptly through the ice. Depth of incision again restricted to 152 m.o.d., controlled by englacial water table.

STAGE 4 Throughout downwastage concentration of princip meltwater activity has moved progressively westwards towards Mennock Water valley. Last stages indicate englacial and extraglacial meltwater concentrated betwee Kiln Hill and Overtown Hill in most direct route to Nith valley. Incision to an altitude of 137 m.o.d.. Finally, with collapse of englacial water table, meltwater flows around Kiln Hill in direction of present stream course.

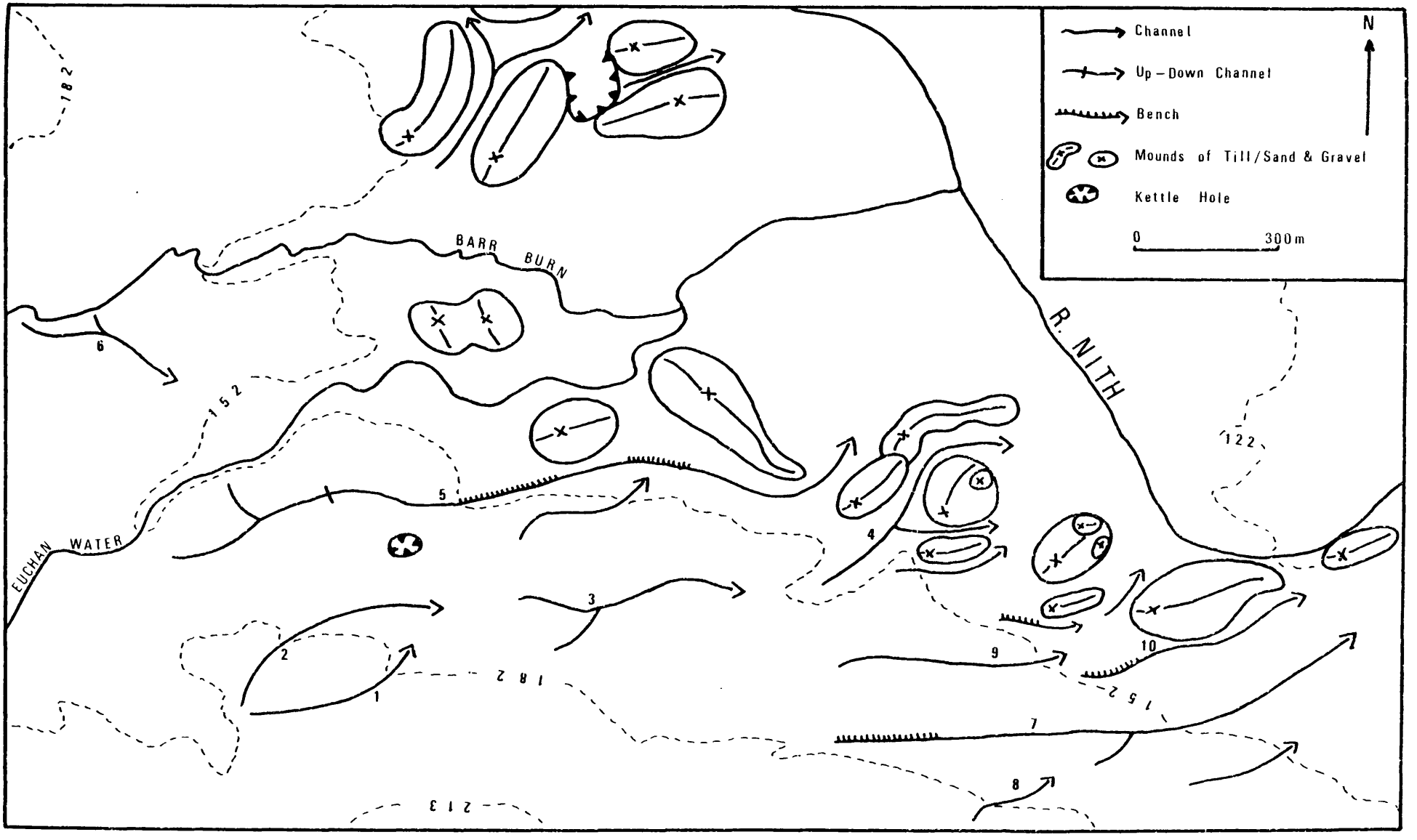


Fig. 5.20. Channel system FE.

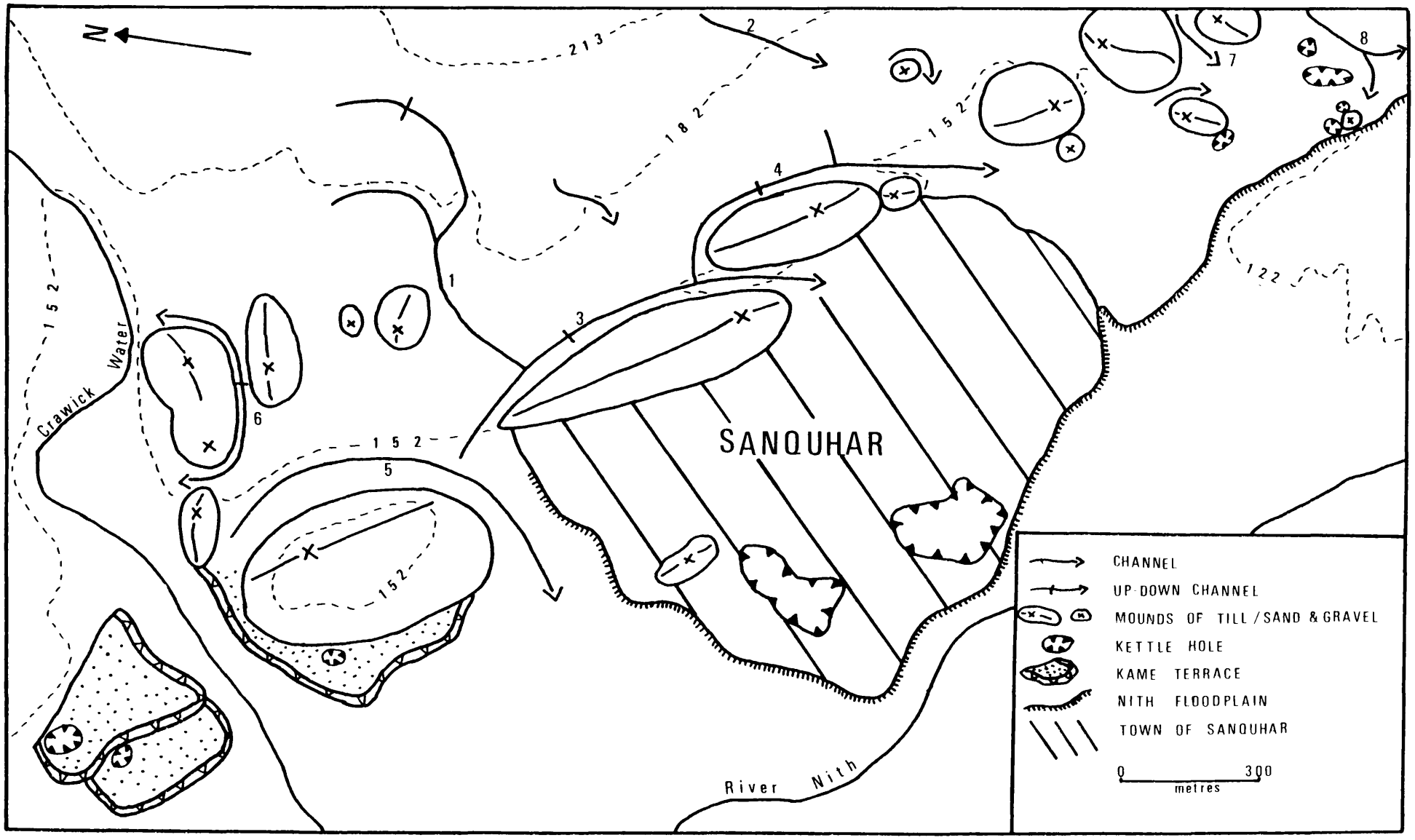


Fig. 5.21. Channel system I.

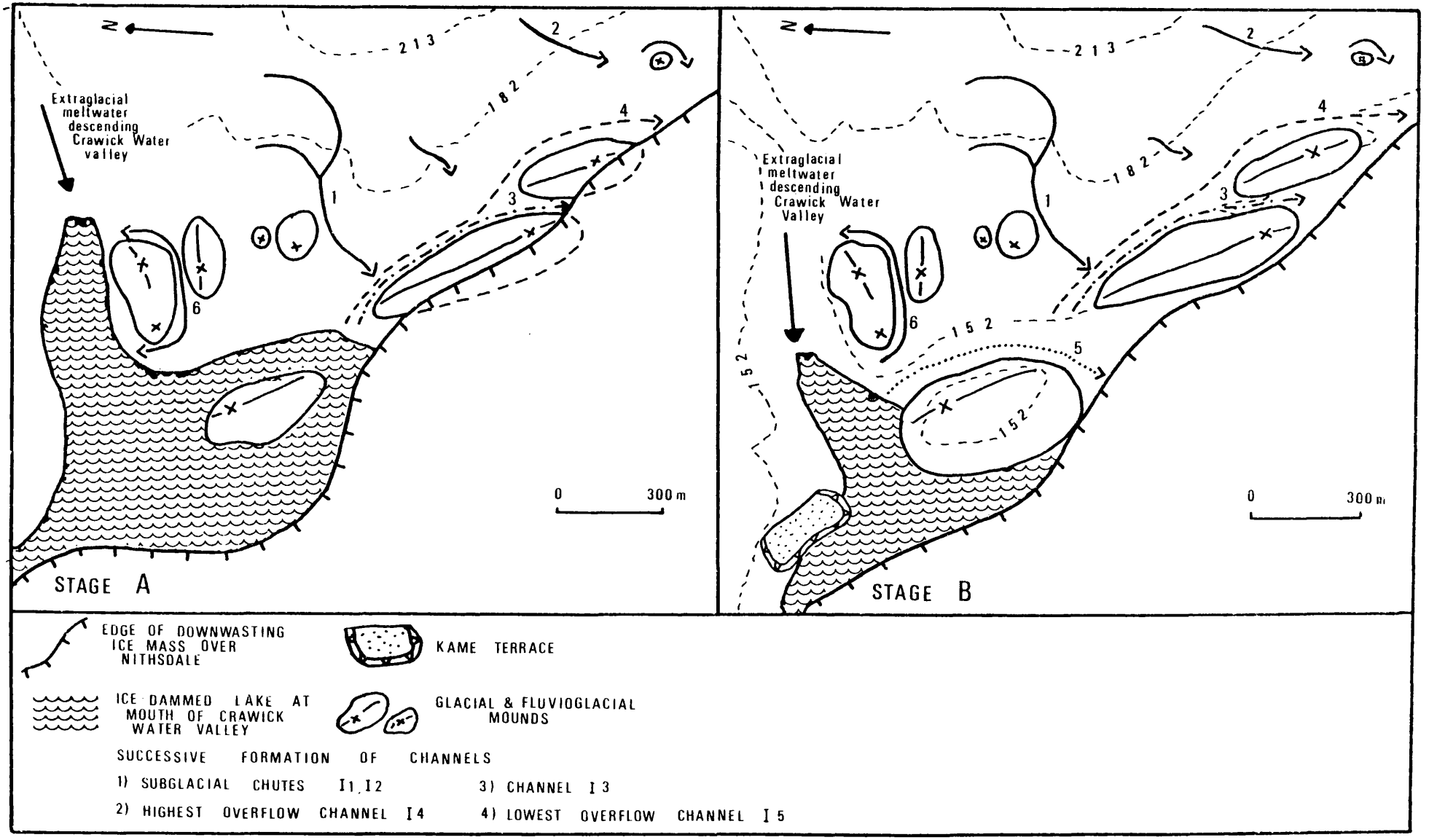


Fig. 5.22. Formation of kame terraces and channel forms at the mouth of the Crawick Water valley.

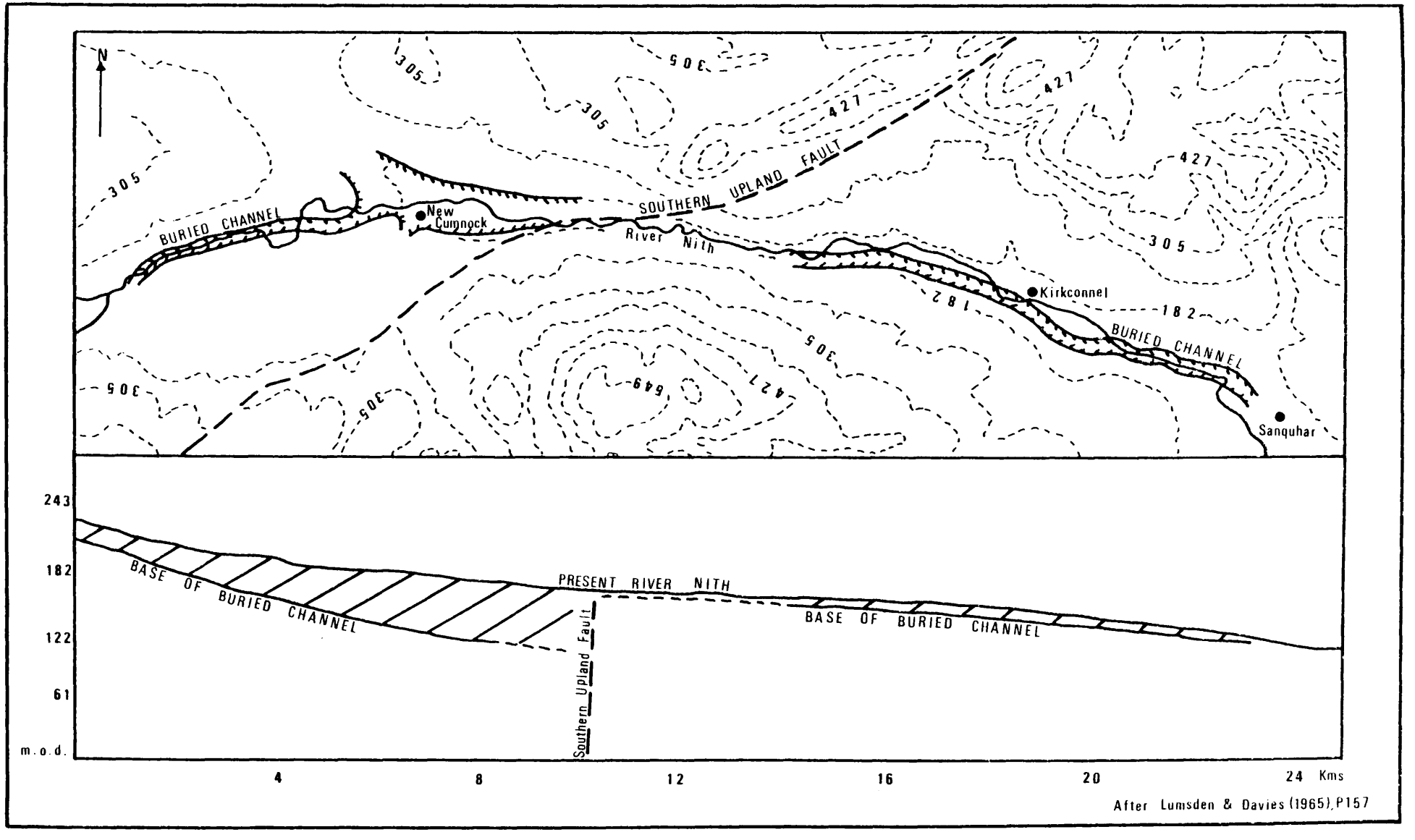


Fig. 5.23. Buried channel of the river Nith.

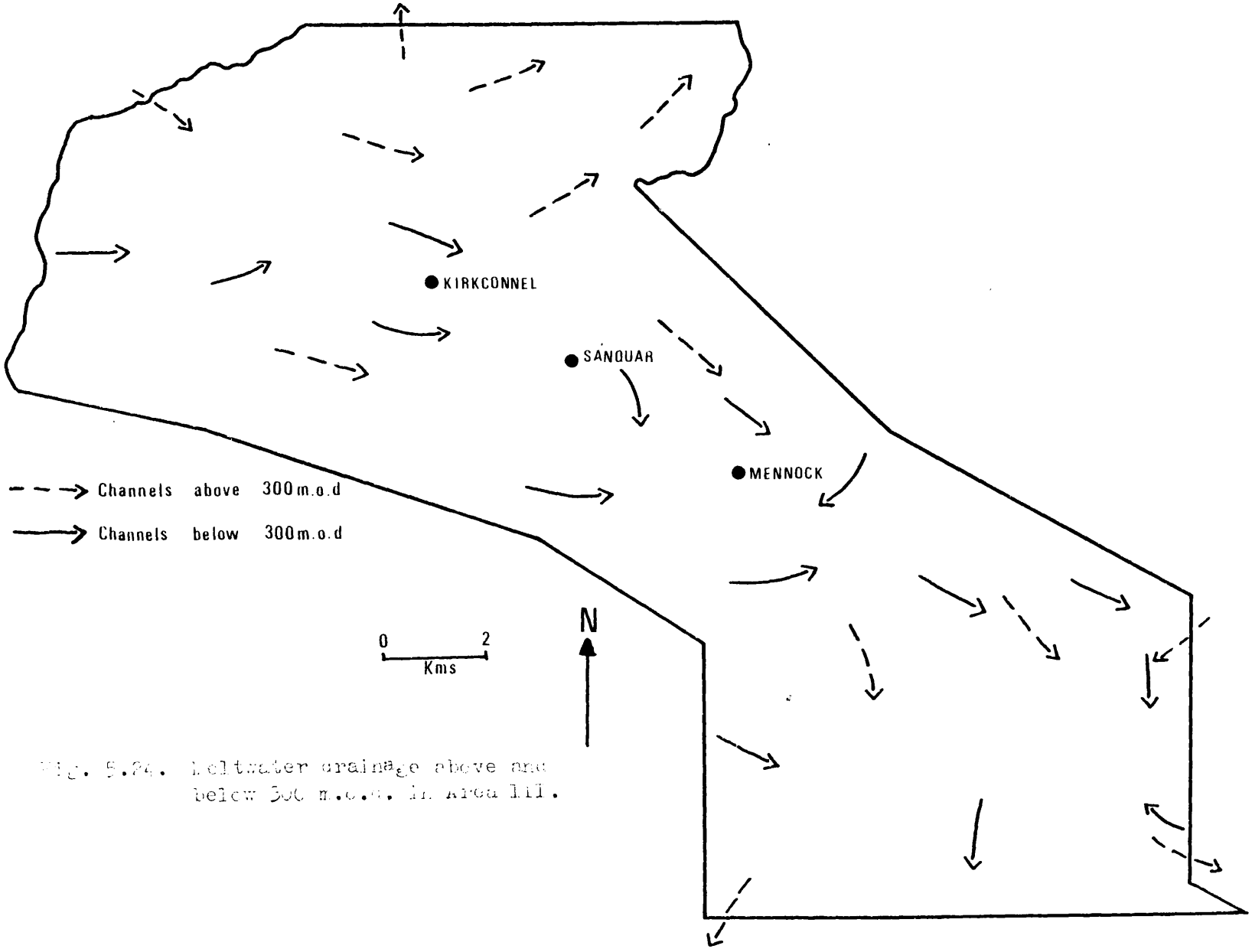


Fig. 5.24. Meltwater drainage above and below 300 m.o.d. in Area III.

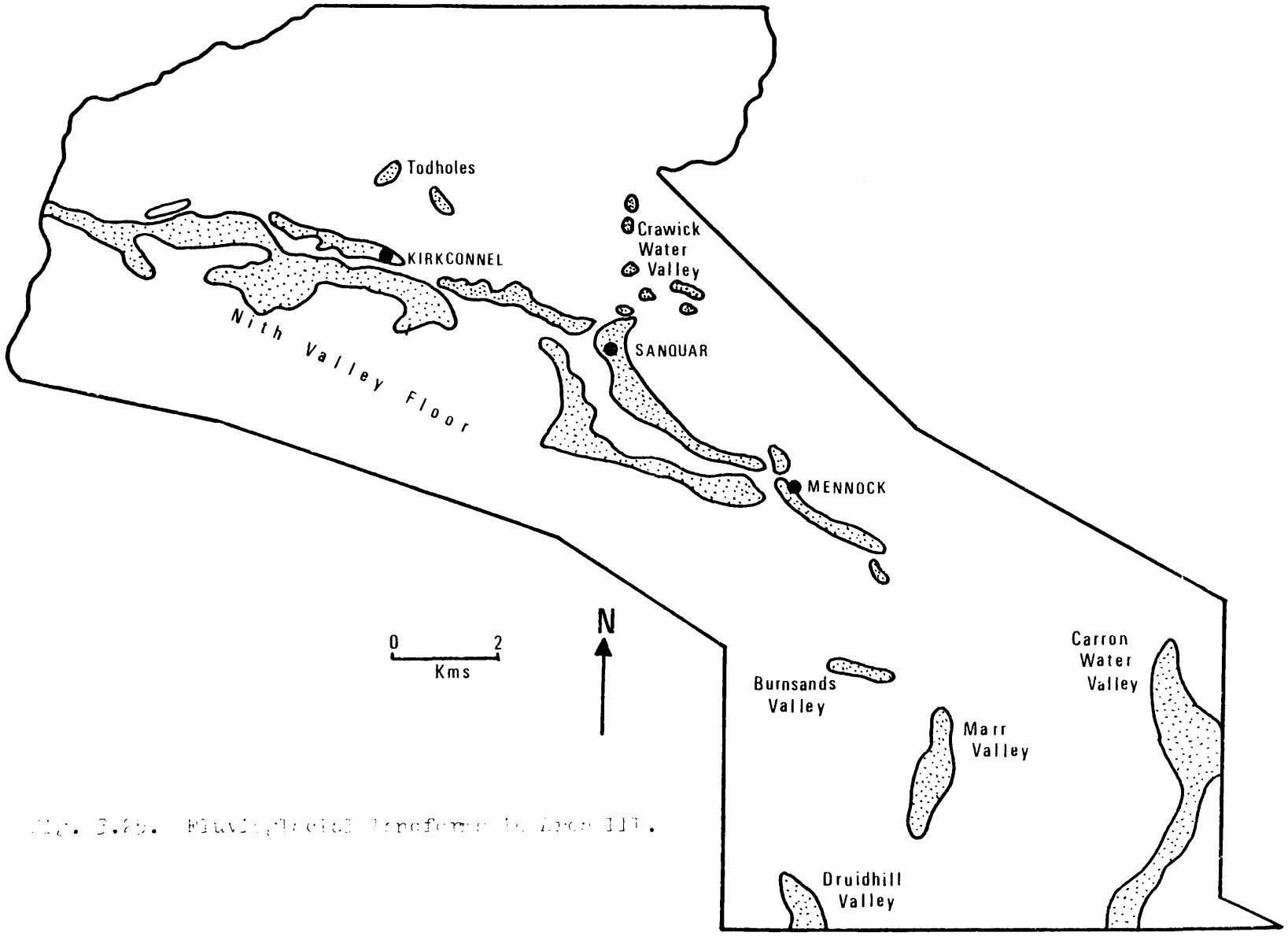


Fig. 3.8b. Fluvioglacial landforms in Area III.

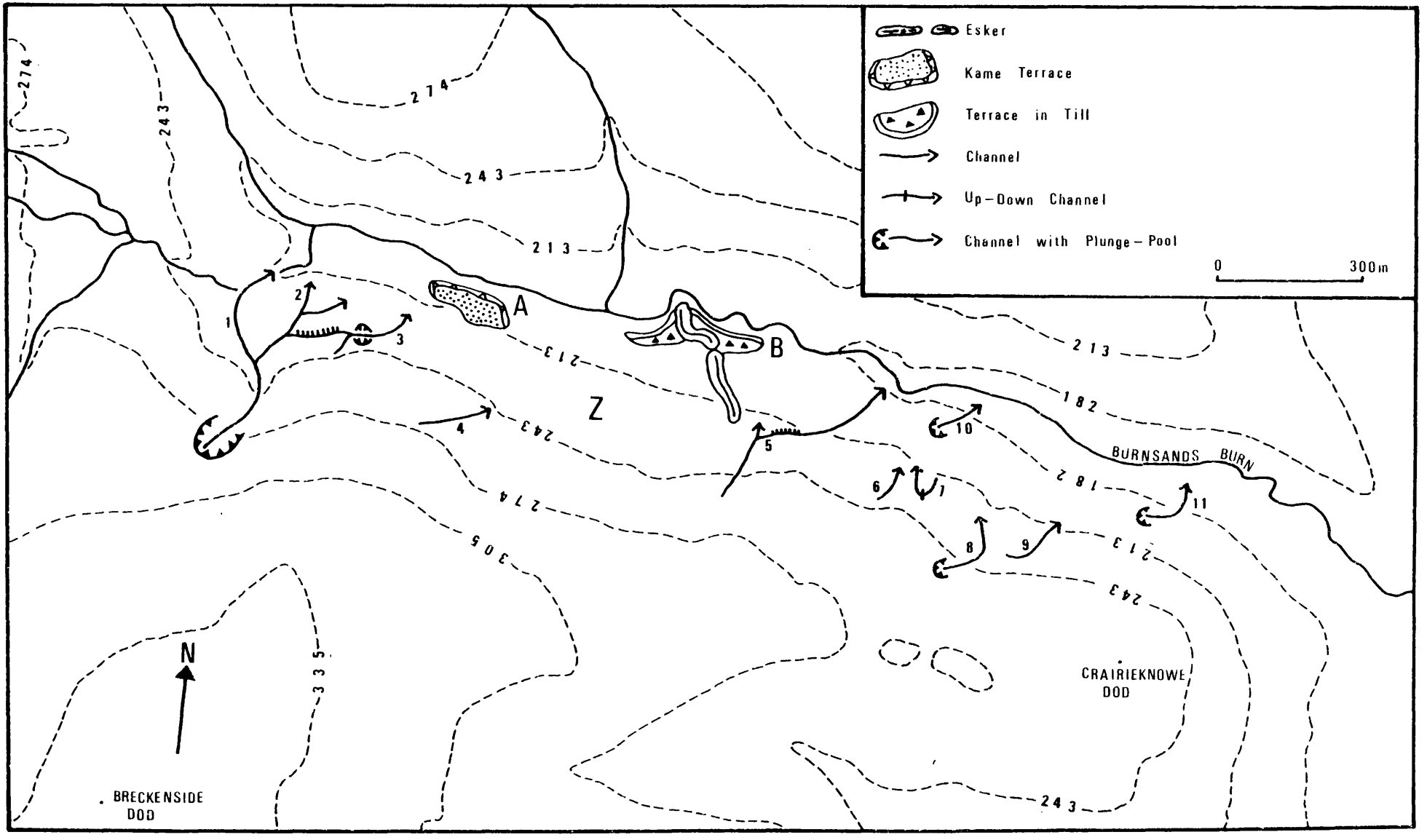


Fig. 5.26. Fluvioglacial landforms in the Burnsands valley.

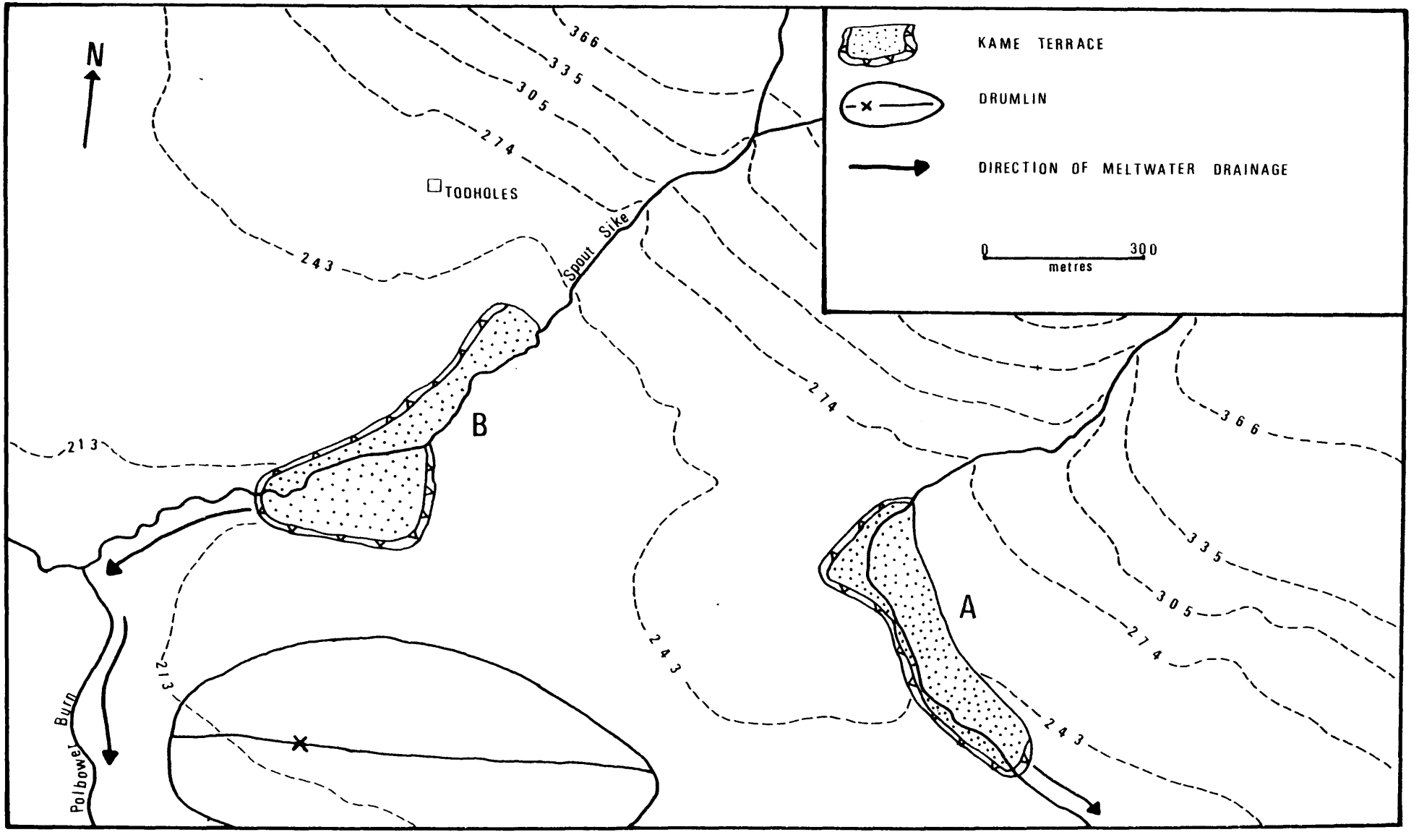


Fig. 5.27. Fluvioglacial landforms at Todholes.

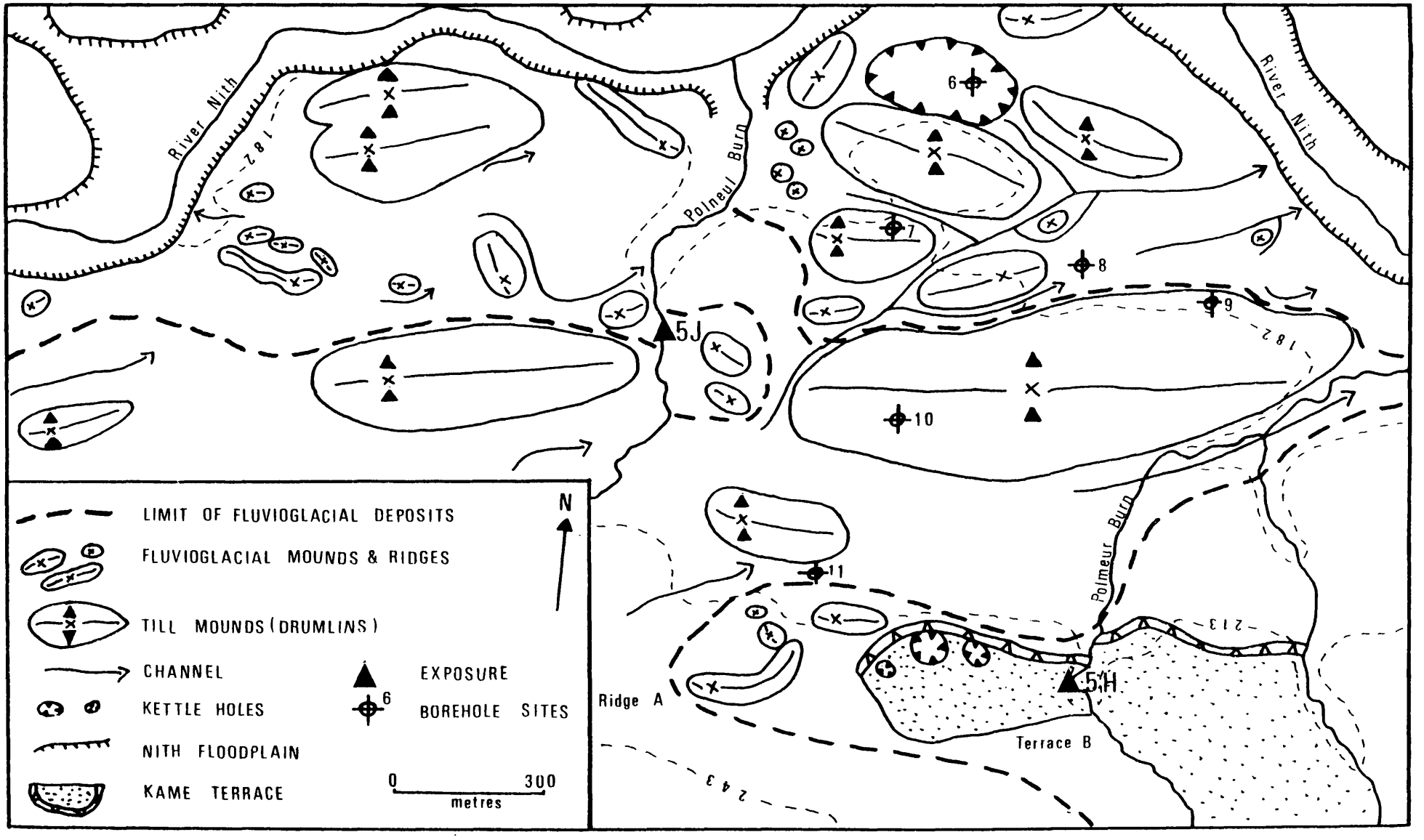


Fig. 5.20. Fluvioglacial landforms near the Nith valley floor.

MAPS AND DIAGRAMS - CHAPTER 6.

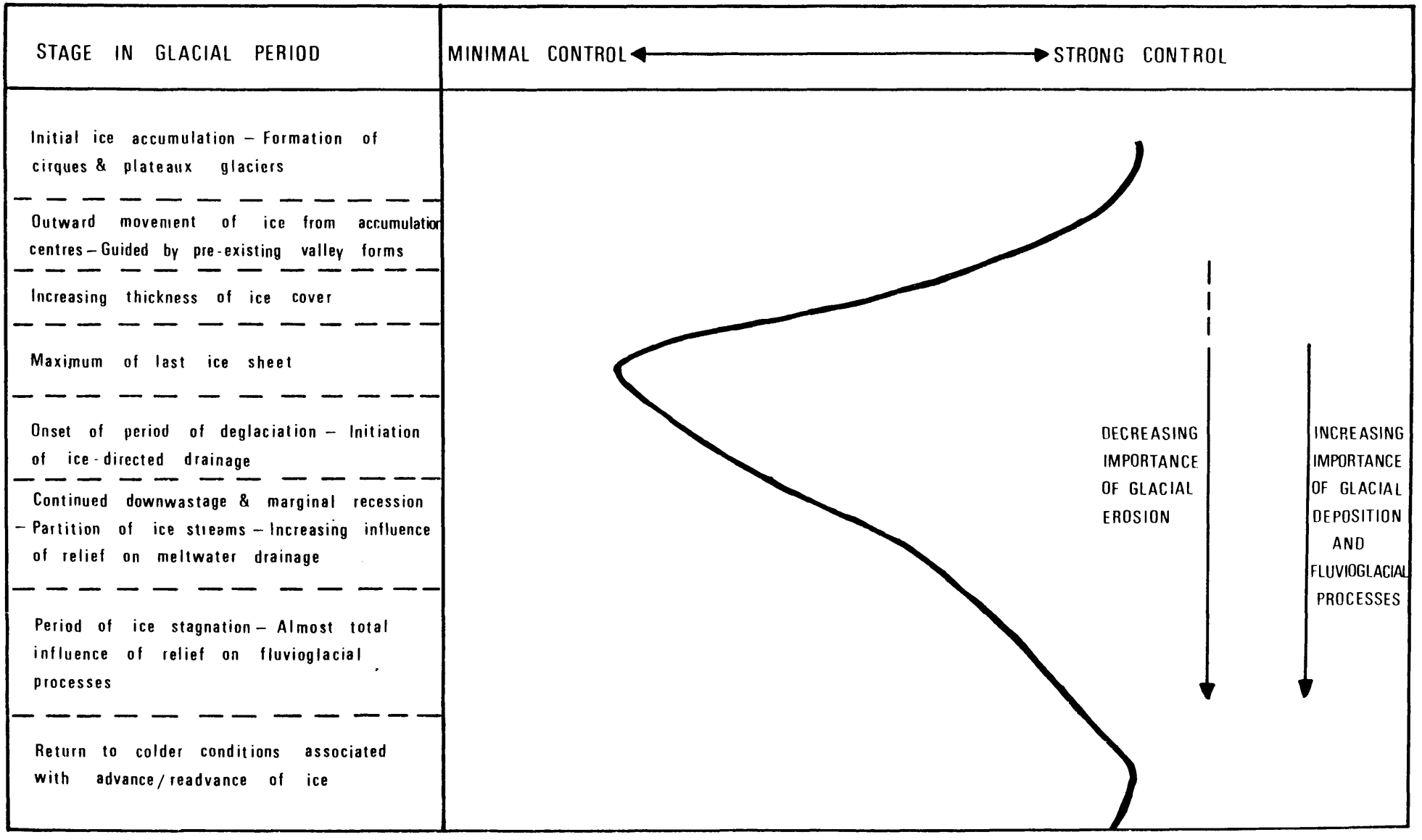


Fig. 6. 1. Importance of underlying relief in controlling glacial and fluvioglacial processes in Upper Nithsdale and Annandale.

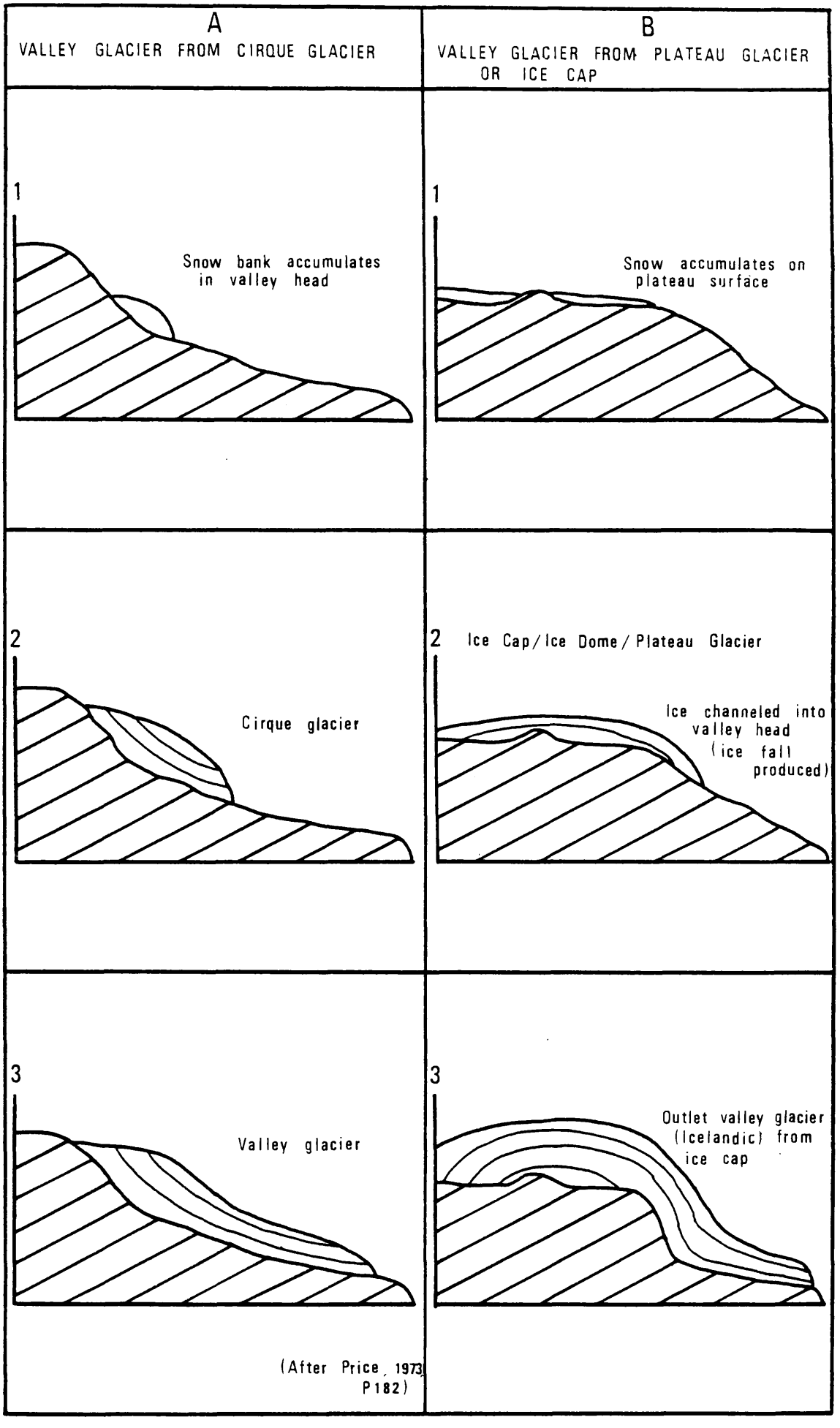


Fig. 6.2. Initiation and development of valley glaciers.

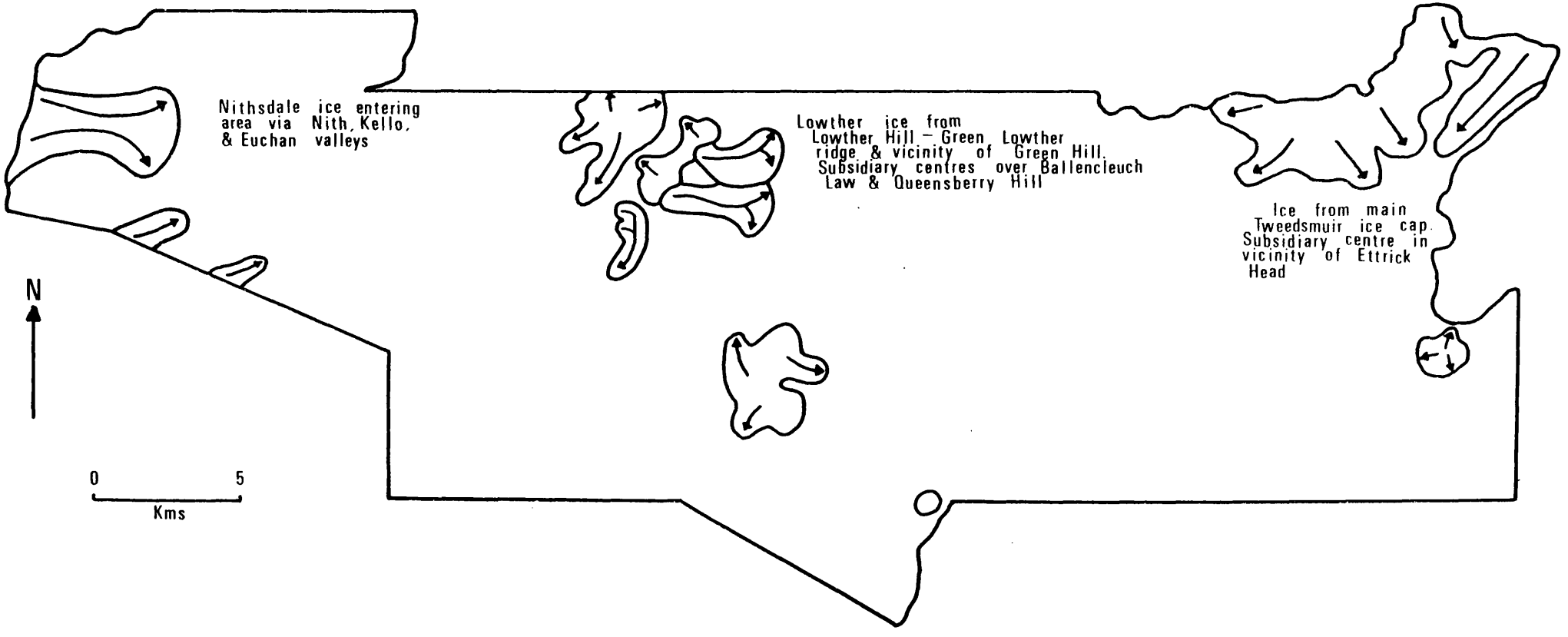


Fig. 6.3. Early stage in the build up and outward movement of ice in Upper Nithsdale and Annandale, leading up to the last glacial maximum.

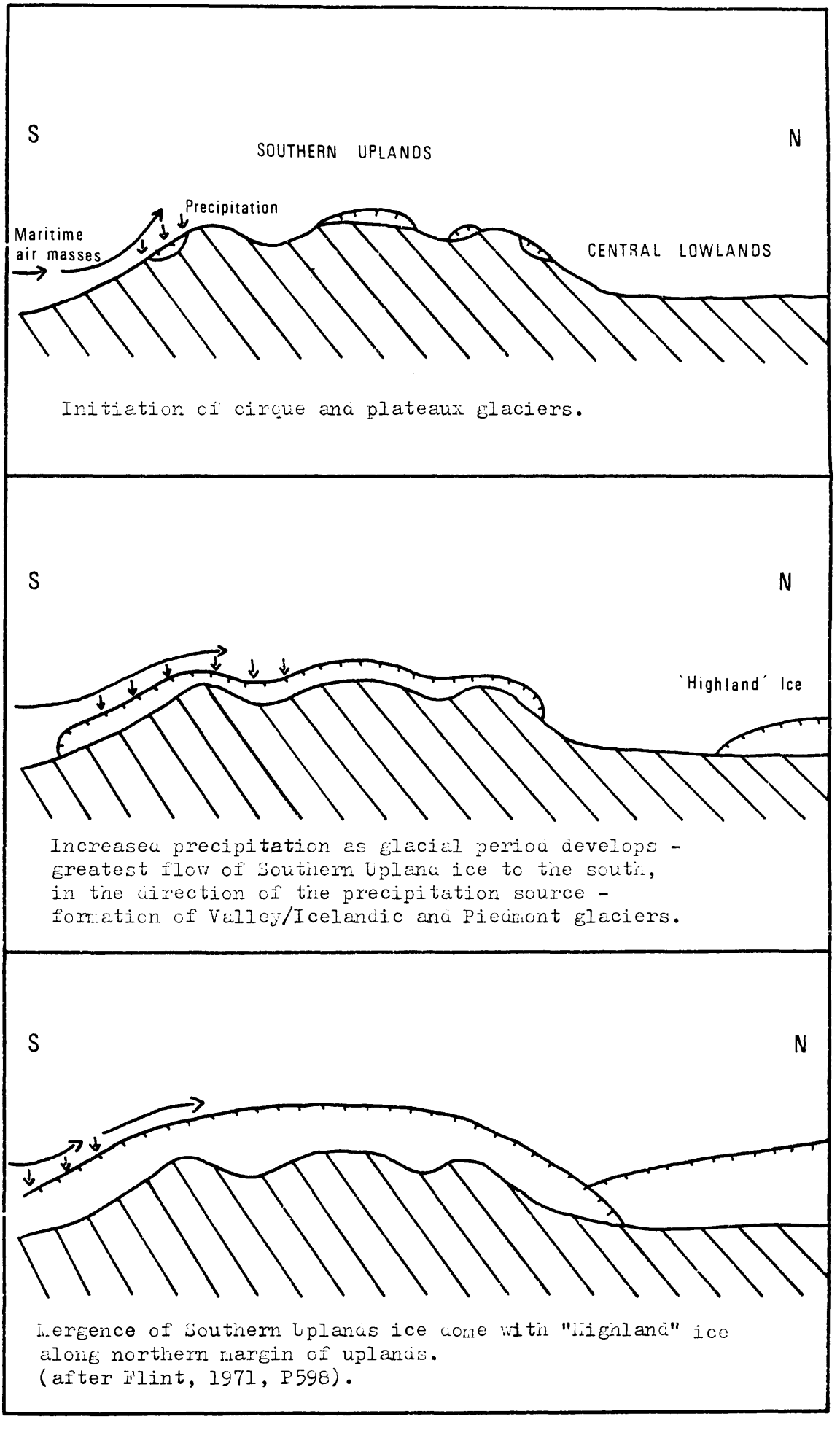


Fig. 6.4. "Highland origin and windward growth" of ice mass over Southern Uplands to the ice sheet stage.

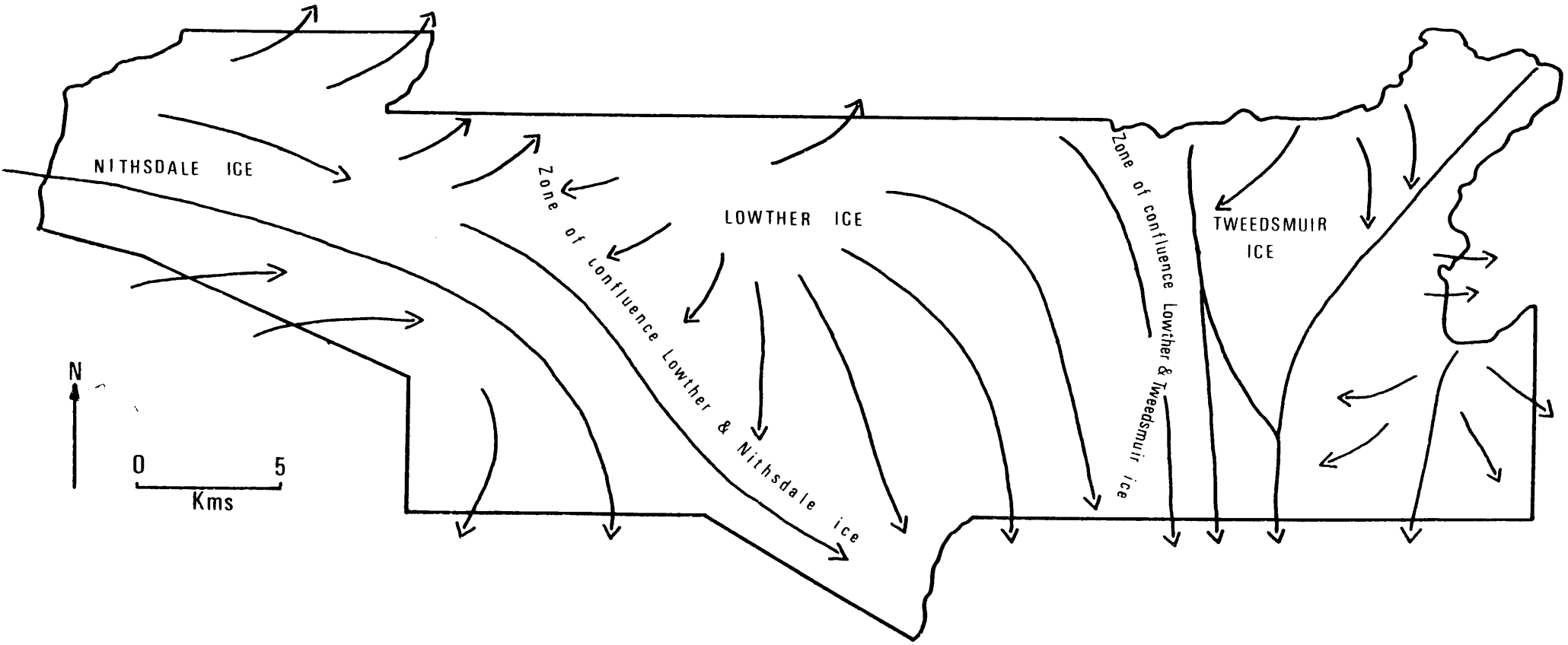


Fig. 6.5. Reconstruction of extent and directions of ice movement from Nithsdale, Lowther and Tweedsmuir source areas at/ near the ice sheet maximum.

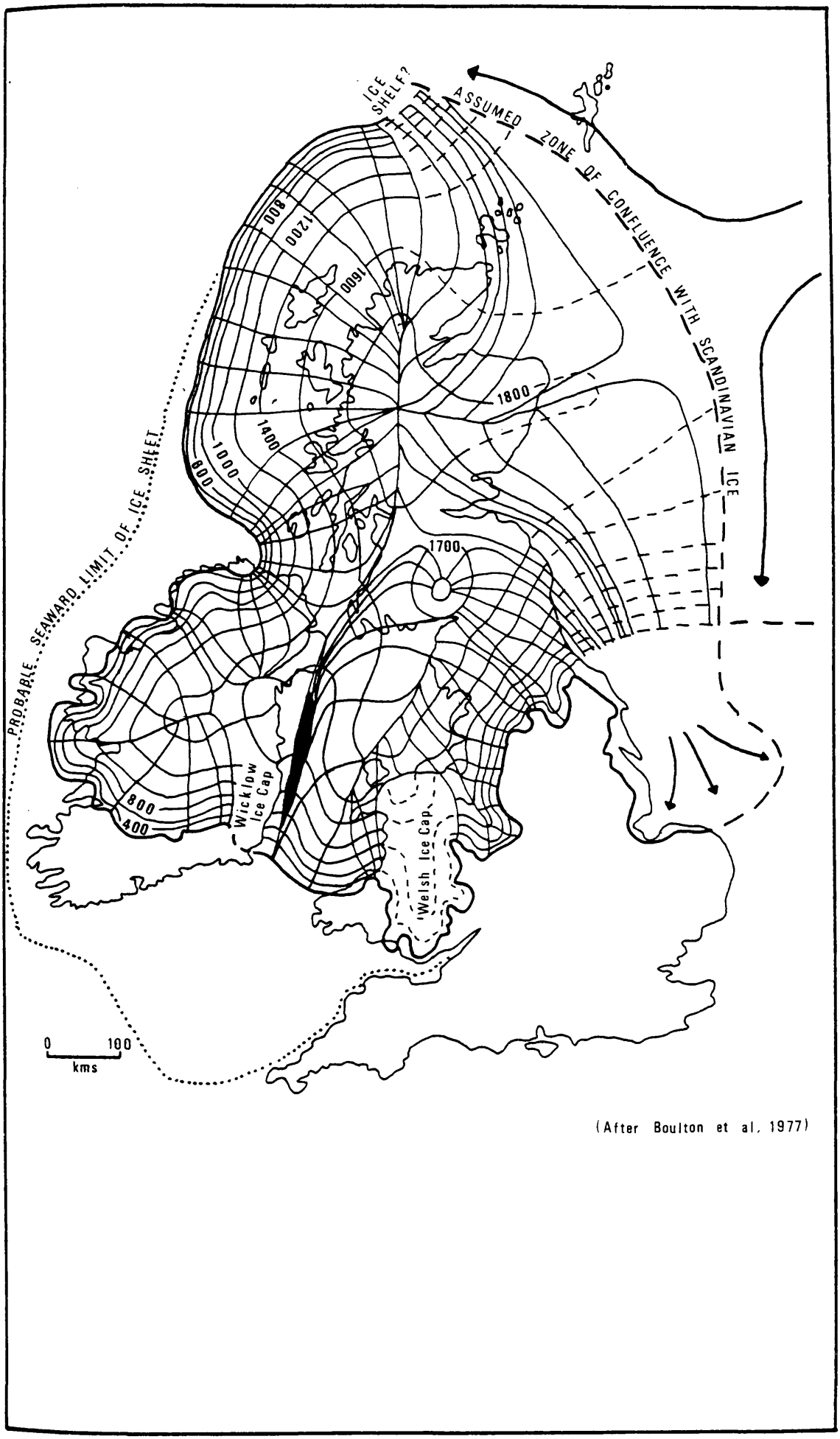


Fig. 6.6. Modelled surface topography and principal flow lines of the last (Late Devensian) ice sheet at its maximum extent.

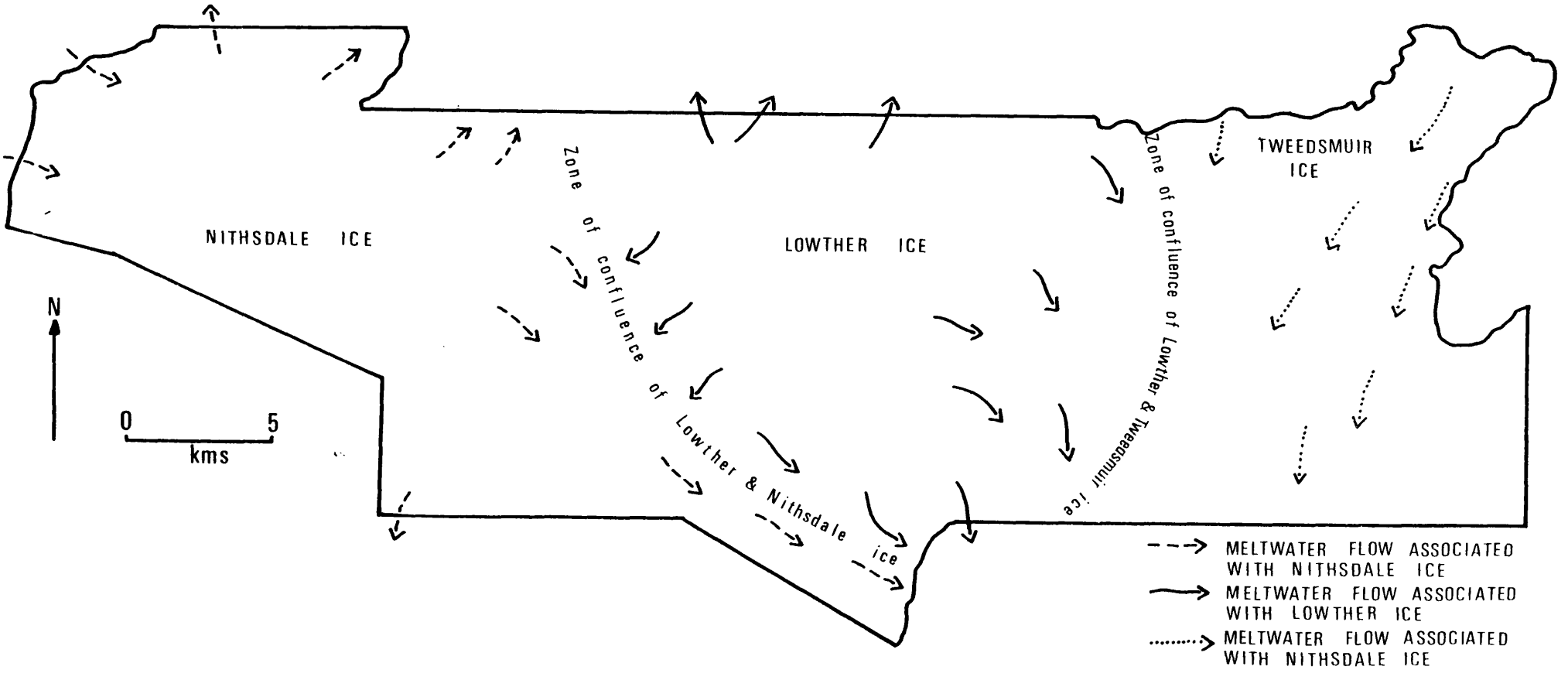


Fig. 6.7. Ice-directed meltwater drainage (above 250 m.o.d.) in Upper Nithsdale and Annandale during the early stages of deglaciation - from alignment of principal meltwater systems and esker ridges.

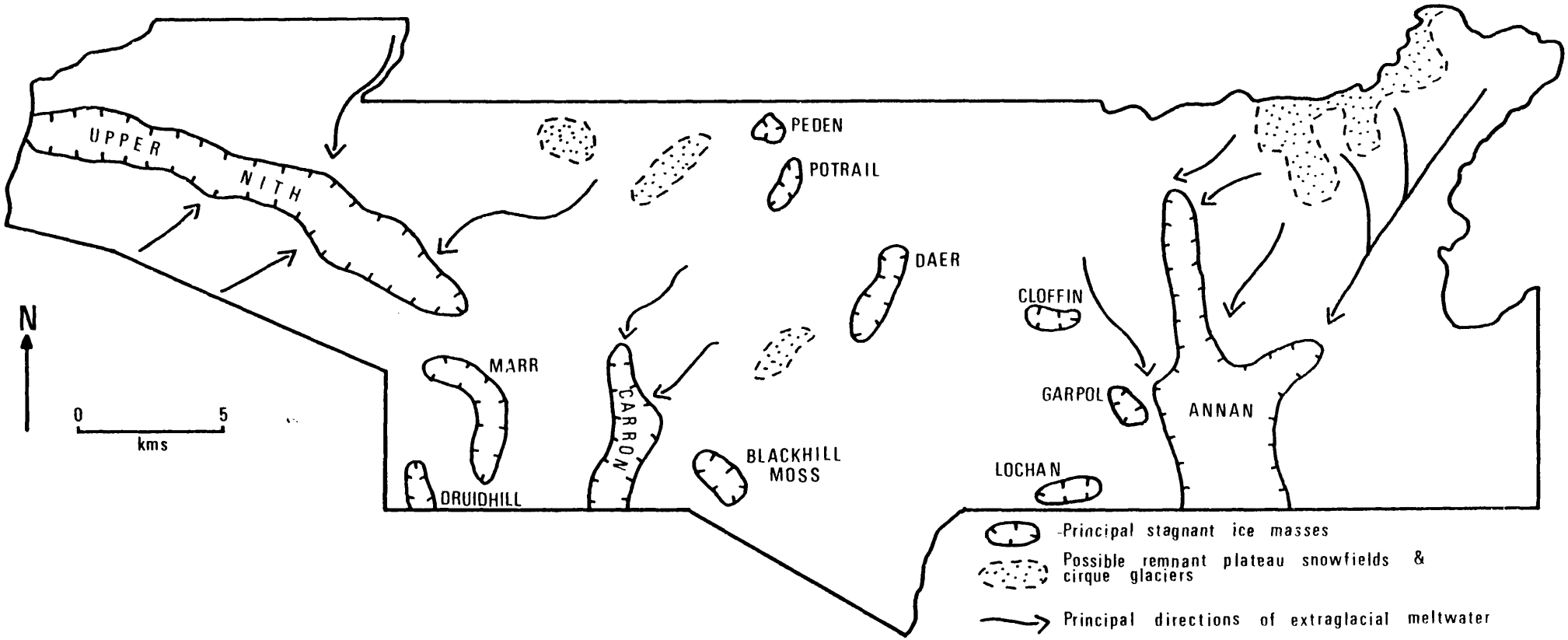


Fig. 6.8. Final stages of deglaciation indicating location of main stagnant ice masses. (The ice margins are drawn to cover the upper limit of stagnant ice deposits. Although it is unlikely that stagnation occurred at the same time in every valley, the map gives an impression of the overall pattern of deglaciation).

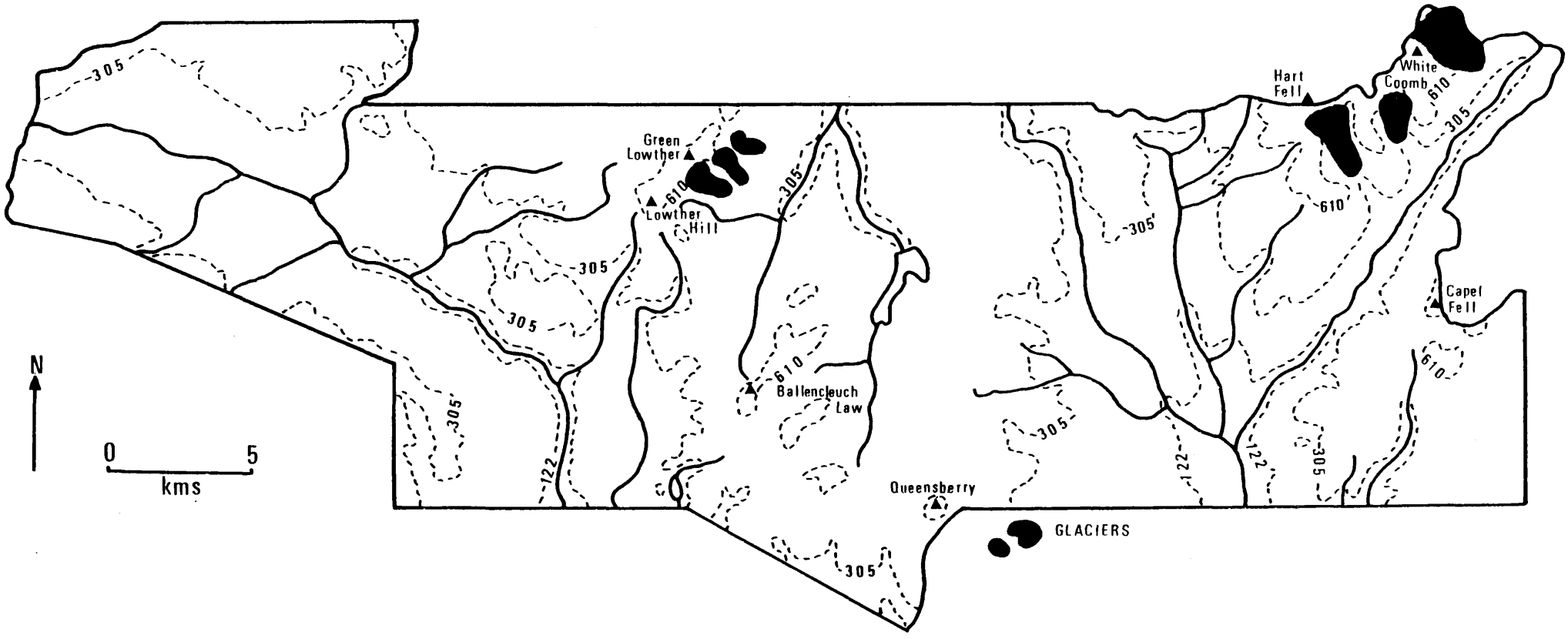


Fig. 6.9. (Re-) Advance glaciers in upper Nithsdale and Annandale during Zone III

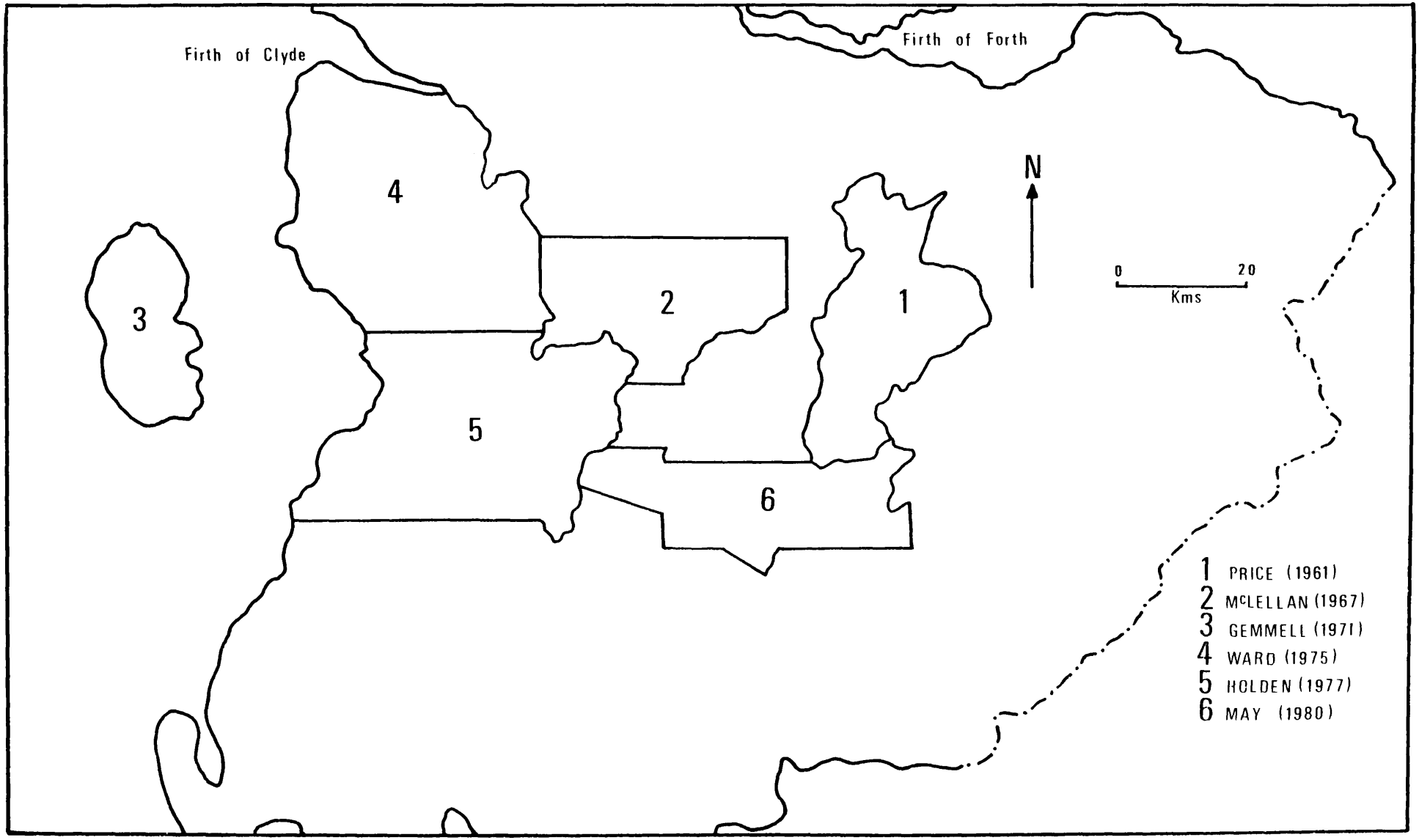


Fig. 6.10. Research in glacial geomorphology at Glasgow University.

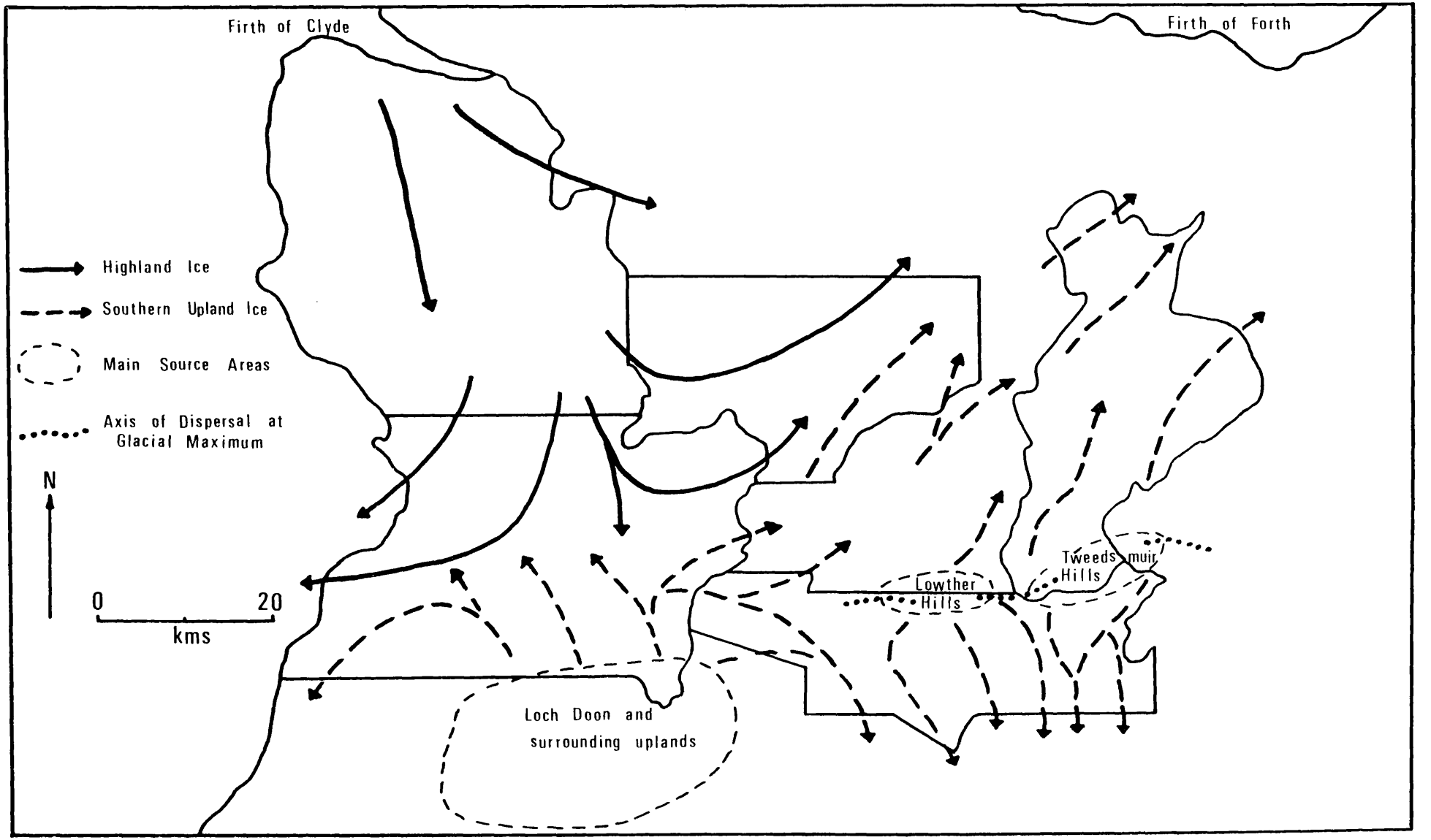


Fig. 6.11. Main source areas and directions of ice movement in west-central and southern Scotland.

2. Upper Nithsdale and Annandale - Tables.

TABLE - CHAPTER 3.

	Altitude of Exposure	Thickness of Till Exposed	CHARACTERISTICS OF THE DEPOSITS
Site 3L Lochan Burn	229 m.o.d.	3m overlying an irregular greywacke surface	Numerous angular, sub-angular and sub-rounded clasts in a dark brown gritty clayey matrix. Majority of clasts are less than 3cm in diameter but boulders up to 75cm are also present. Till is overlain by 1 - 2m of poorly-bedded sands and gravels.
Site 3M Stotfield Gill	229 m.o.d.	7m overlying red sand-stone bedrock	Stiff compact dark brown till containing mainly sub-angular clasts. The clasts are generally less than 2cm in diameter, although forms up to 15cm are also found.
Site 3N Auchencat Burn	213 m.o.d.	4m overlying purply-red greywacke	Dark brown clay tinged red in places containing mainly sub-angular clasts less than 2cm in diameter. Largest clasts only 15cm in diameter.
Site 3P Carrifran Burn	190 m.o.d.	7m Base obscured by slumping	Very tenacious dark grey-brown till containing mainly sub-angular clasts generally less than 2cm in diameter. Larger blocks up to 50cm in diameter are also present.

TABLE 3.1 AREA I - TILL CHARACTERISTICS

P.T.O.

Continued	Altitude of Exposure	Thickness of Till Exposed	CHARACTERISTICS OF THE DEPOSITS
Site 3Q Grey Mare's Tail	300 m.o.d.	18m Base obscured by slumping	Tenacious gritty-clayey matrix, dark brown-grey in colour, containing angular and sub-angular clasts. Most clasts are less than 2cm in diameter, although a large number are 2 - 10cms, the largest being 90cm.
Site 3R Deldcraig Wood	152 m.o.d.	8m Base obscured by slumping	Stiff dark brown clay containing a large number of sub-angular and sub-rounded clasts. Majority of the clasts are less than 2cm in diameter, a large number 3 - 7cm, the largest exceeding 75cm.

TABLE 3.1 CONTINUED

	3L Lochan Burn	3M Stotfield Gill	3N Auchencat Burn	3P Carrifran Burn	3Q Grey Mare's Tail	3R Beldcraig Wood
MEAN STONE ORIENTATION	162°	204.8°	217.2°	189.6°	224.8°	162.8°
CH I - SQUARE	32.1	18.05	48.3	77.5	69.2	132.3
DIP STRENGTH	2	3.92	5.1	13.5	23.1	32
% Cobbles & Boulders > 6cm	26.9	20.1	31.8	31.6	44.7	33.4
% Gravel 2 - 20mm	25.2	26.8	34.9	31.9	20.8	29.6
% Sand 0.06 - 2mm	18.5	38.7	22.6	18.5	20.2	17.0
% Silt & Clay 0.06 - 0.0001mm	29.4	14.4	10.7	18.0	14.3	20.0
Dark Grey Greywacke-Grits %	68	96	72	98	94	72
Green Greywacke-Grits %	6	2	10	-	-	16

TABLE 3.2 STONE ORIENTATION, PARTICLE SIZE AND ERRATIC DATA ON TILLS

P.T.O.

Continued		3L Lochan Burn	3M Stotfield Gill	3N Auchencat Burn	3P Carrifran Burn	3Q Grey Mare's Tail	3R Beldcraig Wood
Red Greywacke-Grits	%	10	-	16	-	2	6
Greywacke-Arkose	%	8	-	-	-	-	-
Siltstone-Shale	%	8	2	2	2	4	6

	DEGREE OF FREEDOM	SIGNIFICANCE LEVEL	
		95%	99.9%
CH I - SQUARE	8	15.51	26.12
DIP STRENGTH	1	3.84	10.83

TABLE 3.2 CONTINUED

TABLES - CHAPTER 4.

	Altitude of Exposure	Thickness of Till Exposed	CHARACTERISTICS OF THE DEPOSITS
Site 4A Glenimshaw Burn	289 m.od.	8m Base obscured by slumping	Very high concentration of clasts, mainly sub-angular in shape in a fairly loose light brown sandy-clayey matrix. Majority of clasts are less than 4-5cm in diameter but some forms up to 20cm in diameter are also present.
Site 4B Mennock Pass	298 m.od.	7m Base obscured by slumping	Numerous angular and sub-angular clasts in a light brown gritty matrix. Majority of clasts are small, less than 3cm in diameter, but forms up to 15cm in diameter are also present.
Site 4C Durisdeer Lane	374 m.od.	7m Rests on Shattered Greywacke	Numerous clasts, mainly angular and sub-angular in shape, in a light brown gritty matrix. Clasts mainly small, less than 4cm in diameter, but with larger cobbles up to 20cm in diameter also revealed.
Site 4D Glenleith Burn	350 m.od.	6m Base obscured by slumping	Numerous mainly angular clasts are revealed in a dark brown gritty matrix. Large number of fines and most clasts less than 4cm in diameter. Larger blocks up to 30cm in diameter are also present.
Site 4E Garroch Water	298 m.od.	8m Base obscured by slumping	Mainly sub-angular clasts are found in a very tenacious reddish-dark brown till. Clasts are generally small, less than 4cm in diameter, although blocks up to 40cm in diameter are also present.

TABLE 4.1 AREA II - TILL CHARACTERISTICS

P.T.O.

Continued	Altitude of Exposure	Thickness of till Exposed	CHARACTERISTICS OF THE DEPOSITS
Site 4F Capel Burn	251 m.od.	12m Rests on shattered Red Sandstone	UPPER TILL - Overlies conformably the lower part of this exposure but is only 1.5-2m in thickness. Fairly tenacious reddish-brown till containing numerous sub-angular and sub-rounded clasts, mainly < 3cm in diameter. Largest clasts 10cm in diameter. Fairly tenacious clayey matrix despite high percentage of clasts present. LOWER TILL - Lower 9m of section. Fairly stiff reddish-brown clay containing fairly scattered clasts. Most of clasts present are less than 4cm in diameter. The largest forms 20-25cms in diameter.
Site 4G White Burn	343 m.od.	8m Base obscured by slumping	Very high concentration of clasts in a grey-brown fairly loose gritty matrix. The majority of the clasts are small, less than 3cm in diameter although larger blocks up to 30cm in diameter are also present.
Site 4H Daer Reservoir	343 m.od.	7m Base obscured by slumping	Numerous angular and sub-angular clasts are revealed in a dark brown gritty-clayey matrix. Clasts are mainly small, less than 4cm in diameter, but larger blocks up to 40cm in diameter are also present.
Site 4J Wintercleuch Burn	351 m.od.	7m Base obscured by slumping	Numerous angular and sub-angular clasts in a brown gritty matrix. The majority of the clasts are less than 3cm in diameter although larger blocks up to 60cm in diameter are also present.

TABLE 4.1 CONTINUED

	4A Glenimshaw Burn	4B Mennock Pass	4C Durisdeer Lane	4D Glenleith Burn	4E Garroch Water	4F Upper Capel Burn	4F Lower Capel Burn	4G White Burn	4H Daer Reservoir	4J Wirtercleuch Burn
MEAN STONE ORIENTATION	164.8°	266°	288.8°	178.4°	98°	138.4°	250°	109.2°	60.4°	199.9°
CH I - SQUARE	19.5	42.8	41.8	66.9	55.2	20.8	60.8	73.9	95.2	49.2
DIP STRENGTH	3.92	0	8.0	13.52	11.52	0	11.52	32.0	28.8	11.52

	DEGREE OF FREEDOM	SIGNIFICANCE LEVEL 95%	99.9%
CH I - SQUARE	8	15.51	26.12
DIP STRENGTH	1	3.84	10.83

TABLE 4.2 STONE ORIENTATION RESULTS

	4A Glenimshaw Burn	4B Mennock Pass	4C Durisdeer Lane	4D Glenleith Burn	4E Garroch Water	4F Capel Burn Upper	4F Capel Burn Lower	4G White Burn	4H Daer Reservoir	4J Wintercleuch Burn
% Cobbles & Boulders										
> 6cm	24.3	38.9	40.7	38.8	35.3	29.0	15.2	33.4	26.6	30.4
% Gravel										
2 - 20mm	41.7	35.5	15.4	25.6	20.6	30.9	27.7	36.2	34.4	32.3
%Sand										
0.06-2mm	24.4	19.4	23.6	22.0	30.3	26.4	41.9	19.9	29.6	27.2
% Silt & Clay										
0.06-0.0001mm	14.6	6.2	20.3	13.6	13.8	13.7	15.1	10.5	10.4	10.1
LOWTHER HILLS ERRATICS %										
Dark Grey Greywacke-Grits	16	98	94	86	78	68	66	92	82	82
Green Greywacke-Grits	-	-	-	-	-	4	8	4	-	-
Red Greywacke-Grits	-	-	-	-	6	2	8	-	4	8
Siltstones	-	2	6	14	16	18	2	4	12	8

PLATE 3C. Blackhope trough.

plate 3D. Grey Mare's Tail waterfall.

Plate E. Evan Water trough.

Plate F. Cirque perched onto side of Blackhope trough.

Plate 3G. Devil's Beef Tub.

Plate 3H. Exposure of till at Grey Mare'
Tail - Site 3Q.

Plate 3I. Drumlins at Tassies Height.

Plate 3J. General view of moraines in the vicinity of Loch Skene.

Plate X. Moraines flanking the Midlaw Burn.

Plate XL. Section produced through moraine ridge by the Tail Burn and close up of morainic constituents.

Plate X. "The Causey", end moraine.

Plate 3N. "Hogg's Well", kettle hole.

Plate 3O. Former floor of Midlaw Loch.

Plate 3P. Breached morainic "dam".

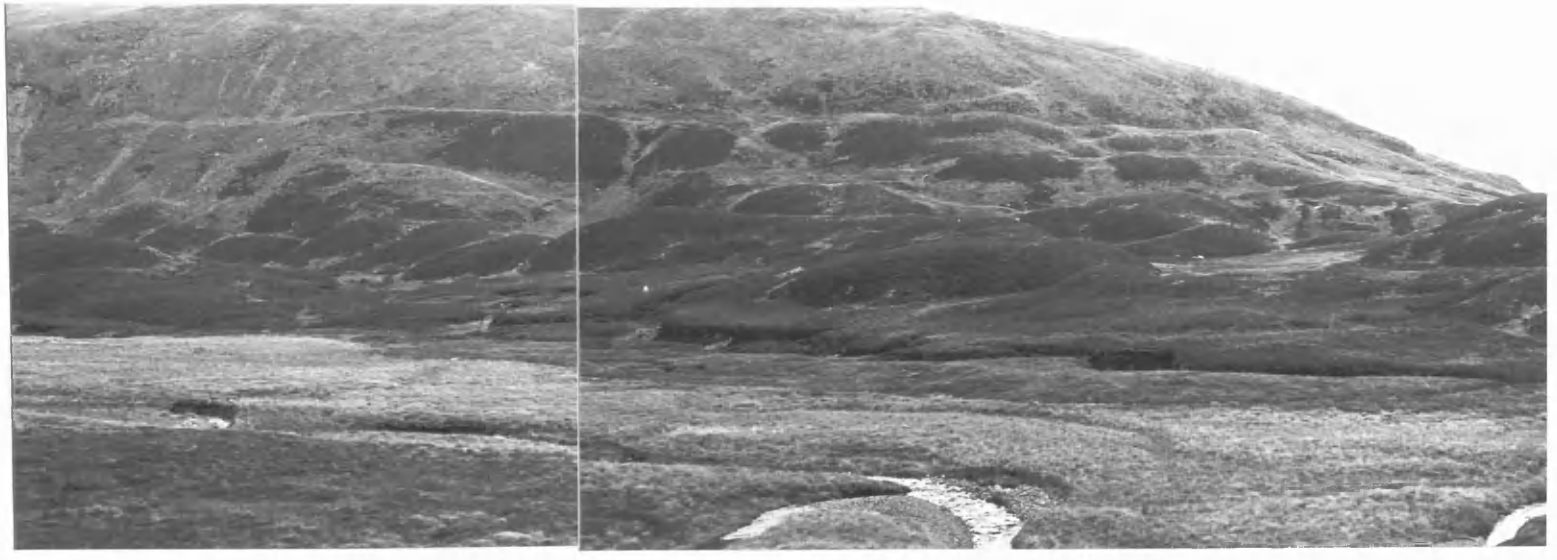


Plate 3Q. Lateral moraines flanking former Midlaw Loch.

Plate 3R. Hummocky moraine.

Plate 3S. Auchencat channel - EE 3.

Plate 3T. Channel FF 2.

Plate 3U. Channel GG 8 - "Hind Gill".

Continued	4A Glenimshaw Burn	4B Mennock Pass	4C Durisdeer Lane	4D Glenleith Burn	4E Garrock Water	4F Capel Burn Upper	4F Capel Burn Lower	4G White Burn	4H Daer Peservoir	4J Wintercleuch Burn
Arkoses	-	-	-	-	-	-	4	-	2	-
NITHSDALE ERRATICS										
Carboniferous/ NRS Sandstone	80	-	-	-	-	-	10	-	-	-
Carboniferous Shale	4	-	-	-	-	-	-	-	-	-
NRS Lava	-	-	-	-	-	-	2	-	-	-
NRS Tuff	-	-	-	-	-	6	-	-	-	-
EITHER										
Quartz	-	-	-	-	-	2	-	-	-	2

TABLE 4.3 PARTICLE-SIZE AND ERRATIC CONTENT OF TILLS CONTINUED

TABLES - CHAPTER 5.

	Altitude of Exposure	Thickness of Till Exposed	CHARACTERISTICS OF THE DEPOSITS
Site 5A Polneul Bridge	185 m.od	6-7 m Base obscured by slumping	Stiff dark brown/dark grey clay containing a fairly high percentage of clasts. Clasts are mainly sub-angular in shape and less than 4cm in diameter but other larger forms up to 20cm in diameter are also present. Till is overlain by capping of 1-2m of unsorted sand and gravel in which there is no evidence of bedding.
Site 5B Glengap Burn	396 m.od	10m Base obscured by slumping	Tenacious dark brown clay matrix containing numerous sub-angular clasts. Clasts are generally less than 4cm in diameter, the largest forms being 15cm in diameter. The majority of the clasts are sub-angular in shape. The till is overlain by 2m of debris derived from mass wastage.
Site 5C Shiel Rig	381 m.od	6m Rests on shattered bedrock	Numerous clasts mainly angular and sub-angular in shape are revealed in a light brown clayey matrix. Clasts are generally less than 3cm in diameter, the largest forms being 15cm.
Site 5D Whing Burn Ford	182 m.od	9m Base obscured by slumping	UPPER TILL - 1.5-2m of a light brown loose earthy matrix containing a fairly high percentage of sub-angular and sub-rounded clasts. The majority of the clasts are less than 5cm in diameter although blocks up to 50cm in diameter are also present. LOWER TILL - 6-7m of stiff dark brown/grey clayey matrix containing scattered clasts almost all of which are sub-angular in shape. A high percentage of the clasts are less than 3cm in diameter but blocks up to 30cm in diameter are also present. Lower unit merges vertically into upper till.
Site 5E Old Mains	122 m.od	8m Rests on bedrock	UPPER TILL - Very sandy till, varying in thickness between 1.5-4m. Numerous light brown sandstone blocks up to 1m in diameter are found scattered through the matrix - indeed 90-95% of all the clasts are of sandstone origin giving a very sandy matrix generally. A large number of the clasts are vertically aligned and often represented

TABLE 5.1 AREA III - TILL CHARACTERISTICS

Continued	Altitude of Exposure	Thickness of till Exposed	CHARACTERISTICS OF THE DEPOSITS
Site 5E Old Mains cont'd	cont'd	cont'd	as drop stones suggestive of flowage or dropping into a semi-liquid till unit. Sand and fine gravel lenses are found within the till unit. Most of the included clasts are angular in shape. The upper till is overlain by 3m of sub-rounded and sub-angular pebbles, mainly the former in a fine gravelly matrix. There is no evidence of stratification.
			LOWER TILL - 3-4m of very stiff dark brown/dark grey clayey matrix containing only scattered clasts. Clasts are generally sub-angular in shape and less than 4cm in diameter, but blocks up to 50cm in diameter are also found. As before, the lower unit merges vertically into the upper till.
Site 5F Burnsands Burn	185m.od	8m Base obscured by slumping	A very tenacious reddish-brown clayey matrix containing a wide variety of clast sizes. There are a large number of fines less than 1.5cm and the majority of the clasts are less than 8cm in diameter. The clasts vary between sub-angular and sub-rounded in terms of shape. The till is overlain by 1m of loose material produced by mass wastage.
Site 5G Cairn Burn	258 m.od	5m Base obscured by slumping	Dark brown clayey matrix tinged with grey in places. Contains scattered sub-angular and sub-rounded clasts mainly less than 3cm in diameter although larger forms up to 40cm in diameter are also present.

TABLE 5.1 CONTINUED

	5A Polneul Bridge	5B Glengap Burn	5C Shiel Rig	5D Whing Burn Ford	5E Old Mains	5F Burnsands Burn	5G Cairn Burn
MEAN STONE ORIENTATION	339.6°	253.2°	233.6°	234.5°	244°	176°	164.4°
CH I- SQUARE	36.4	111.3	51.9	33.5	31.4	37.8	75.4
DIP STRENGTH	3.9	35.3	20.5	3.9	13.5	9.7	18

	DEGREE OF FREEDOM	SIGNIFICANCE LEVEL 95%	99.9%
CH I - SQUARE	8	15.51	26.12
DIP STRENGTH	1	3.84	10.83

TABLE 5.2 STONE ORIENTATION RESULTS

	5A Polneul Bridge	5B Clengap Burn	5C Shiel Rig	5D Whing Burn Ford	5E Old Mains	5F Burnsands Burn	5G Cairn Burn
Greywacke/Grits	72	30	82	84	72	66	58
Siltstones	6	70	18	10	8	34	42
Quartz	2	-	-	-	-	-	-
Quartz-Grits	-	-	-	2	-	-	-
Quartzite	-	-	-	2	-	-	-
Carboniferous Sandstone	14	-	-	-	14	-	-
Shale	2	-	-	-	2	-	-
O.R.S. Lava	2	-	-	-	-	-	-
Tuff	-	-	-	-	4	-	-
Felsite	-	-	-	2	-	-	-
Lava Conglomerate	2	-	-	-	-	-	-

TABLE 5.3 AREA III - ERRATIC CONTENT OF TILLS (PERCENTAGES)

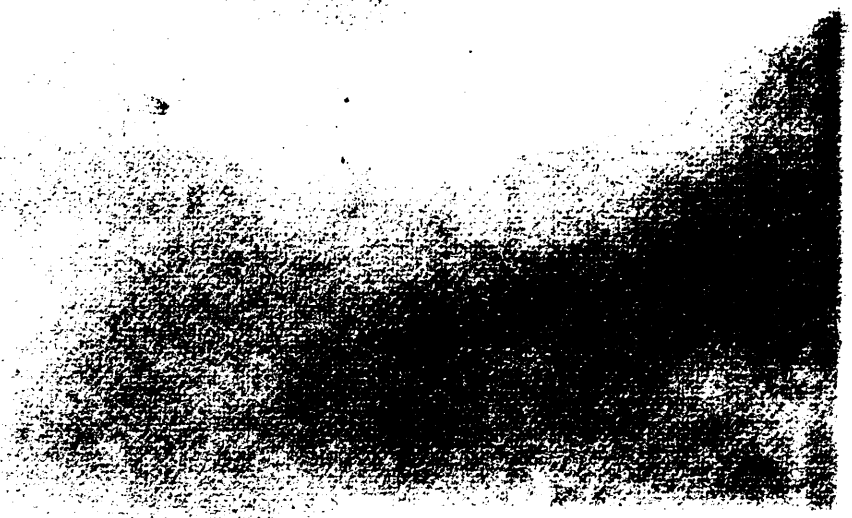
	5A Polneul Bridge	5B Glengap Burn	5C Shiel Rig	5D Whing Burn Ford	5E Old Mains	5F Burnsands Burn	5G Cairn Burn
% Cobbles & Boulders							
>6cm	22.3	37.8	18.8	13.9	18.8	25.1	29.3
% Gravel							
2 - 20mm	32.4	33.8	40.9	35.5	36.5	31.4	31.1
% Sand							
0.06 - 2mm	21.9	17.3	23.4	29.4	25.4	23.5	22.9
% Silt & Clay							
0.06 - 0.0001mm	23.4	11.1	16.9	21.2	19.3	20.0	16.7

TABLE 5.4 PARTICLE-SIZE ANALYSIS OF TILLS

DRUMLIN SWARMS		ALTITUDE OF CREST(m.o.d.)	LENGTH	MAXIMUM WIDTH	CONSTITUENTS
A	1	233	1.5km	380m	Till/Rock
	2	225	500m	230m	Till/Rock
	3	228	950m	450m	Till/Rock
	4	192	750m	230m	Till/Rock
B	1	205	420m	270m	Till
	2	207	500m	210m	Till
	3	189	440m	170m	Till
	4	197	1.12km	320m	Till/Rock
C	1	172	410m	220m	Till
	2	185	290m	150m	Till
	3	183	420m	290m	Till
	4	186	400m	100m	Till
D	1	230	1.26km	640m	Till/Rock
	2	238	900m	420m	Till/Rock
	3	184	410m	210m	Till/Rock
E	1	213	350m	120m	Till/Rock
	2	189	190m	120m	Till/Rock
	3	188	350m	100m	Till/Rock
	4	191	440m	190m	Till/Rock
F	1	183	220m	120m	Till/Rock
	2	179	120m	100m	Till/Rock
	3	176	200m	100m	Till/Rock
	4	172	200m	120m	Till/Rock
	5	174	120m	80m	Till/Rock
	6	183	100m	80m	Till/Rock
	7	170	210m	90m	Till/Rock
	8	173	200m	100m	Till/Rock
	9	170	140m	100m	Till/Rock
	10	172	190m	80m	Till/Rock
	11	172	200m	110m	Till/Rock
	12	173	240m	80m	Till/Rock
	13	184	600m	220m	Rock
	14	185	540m	200m	Rock

TABLE 5.5 AREA III - DRUMLINOID FORMS

3. Upper Nithsdale and Annandale - Plates.



PLATES - CHAPTER 3.

Plate 3A. Moffat Water trough

Plate 3B. Carrifran trough.

Plate IV. General view of eastern flank of Annandale, illustrating channel systems CC, EE, FF, and GG.

Plate 3W. Kame terrace "A".

Plate 3K. Ice-wedge cast exposed in kame terrace "A" - Site 3S.

Plate 3Y. Kame terrace "C".

Plate 3Z. Fluvioglacial landforms in the vicinity of Dyke Farm.

Plate 3AA. Fluvioglacial landforms in the Garpol Water valley.

Plate 3BB. Esker I in Lochan valley.

Plate 3CC. Esker 2 in Kinnel water valley.

Plate 3DD. Esker 3 in Lochan valley.

PLATES - CHAPTER 4.

Plate 4A. Carron trough, (Dalveen Pass).

Plate 4B. Mennock trough.


LANG CIRQUE
PEDEN CIROUE
Lang Cleuch
Riccart Cleuch
Potrenick Burn
Peden Burn

Plate 4c

Plate 4D. Col linking Enterkin trough to Carron trough.

Plate 4E. Glacially-breached col at the head of the Kirk trough.

Plate 4F. Exposure in Lower Capel valley - Site 4F.

Plate 4G. Moraines in the Lang Cleuch valley.

Plate 4H. Channel B1 looking northwards.

Plate 4I. General view of upland edge which represents south-west boundary of Area II.

Plate 4J. Channel P12 looking north-west to Spur O.

Plate 4K. Rock-step in the floor of channel P12.

Plate 4L. View northwards to mouth of Capel valley showing terrace forms on either side.

Plate 4K. View westwards across level surface of terrace GG.

Plate 4N. Esker and kame terrace at Nether Pingland.

PLATES - CHAPTER 5.

Plate 5A. General view of Nith valley in the vicinity of Kirkconnel and Sanquhar.

Plate 5B. Crawick trough.

Plate 5C. Exposure of tills at Old Mains - Site 5E.

Plate 5D. Drop-stones in upper till unit at Old Mains Site 5E.

Plate 5E. Drumlin form along lower flank of the Nith valley near Kirkconnel.

Plate 5F. Channel G6, with channel G2 on the far spur.

Plate 5G. Plunge-pool representing in-take to channel S1.

Plate 5H. Channel system J.

Plate 5I. Channel system BB.

Plate 5J. Kame terraces at the mouth of the Crawick Water valley.

Plate 5K. Esker and terrace form in Burnsands valley.

Plate 5L. Large kame terrace on the flanks of Nithsdale to the west of Kirkconnel

Plate XI. Fog occupying the Nith valley floor in much the same way as a remnant ice mass must have done at an advanced stage in the deglaciation of the area.

PLATES - CHAPTER 6.

Plate 6A. Morsarjokull, south-west Iceland, descending from Vatnajokull ice cap. The Carrifran and Blackhope troughs are believed to have formed in a similar manner.

KEY

SHOULDER OF GLACIAL TROUGH

CIRQUE

ARÊTE

GLACIALLY-BREACHED COL

ROCHE MOUTONNÉE

STRIATION

ICE-MOULDED FORM

MORAINE

MELTWATER CHANNEL

MELTWATER BENCH

UP-DOWN CHANNEL

FLUVIOGLACIAL MOUNDS & RIDGES

KAME TERRACE

DELTA-KAME TERRACE

MARGINAL LAKE DEPOSITS

DRUMLIN FORMS

TILL

SOLIFLUCTED MATERIAL

FLUVIOGLACIAL SANDS & GRAVELS

BEDROCK/PEAT/ALLUVIUM

▲4C SITE REFERRED TO IN TEXT

●125 SPOT HEIGHTS (m.o.d)

A—B LINE OF SECTION - REFERRED TO IN TEXT

0 1 km

N

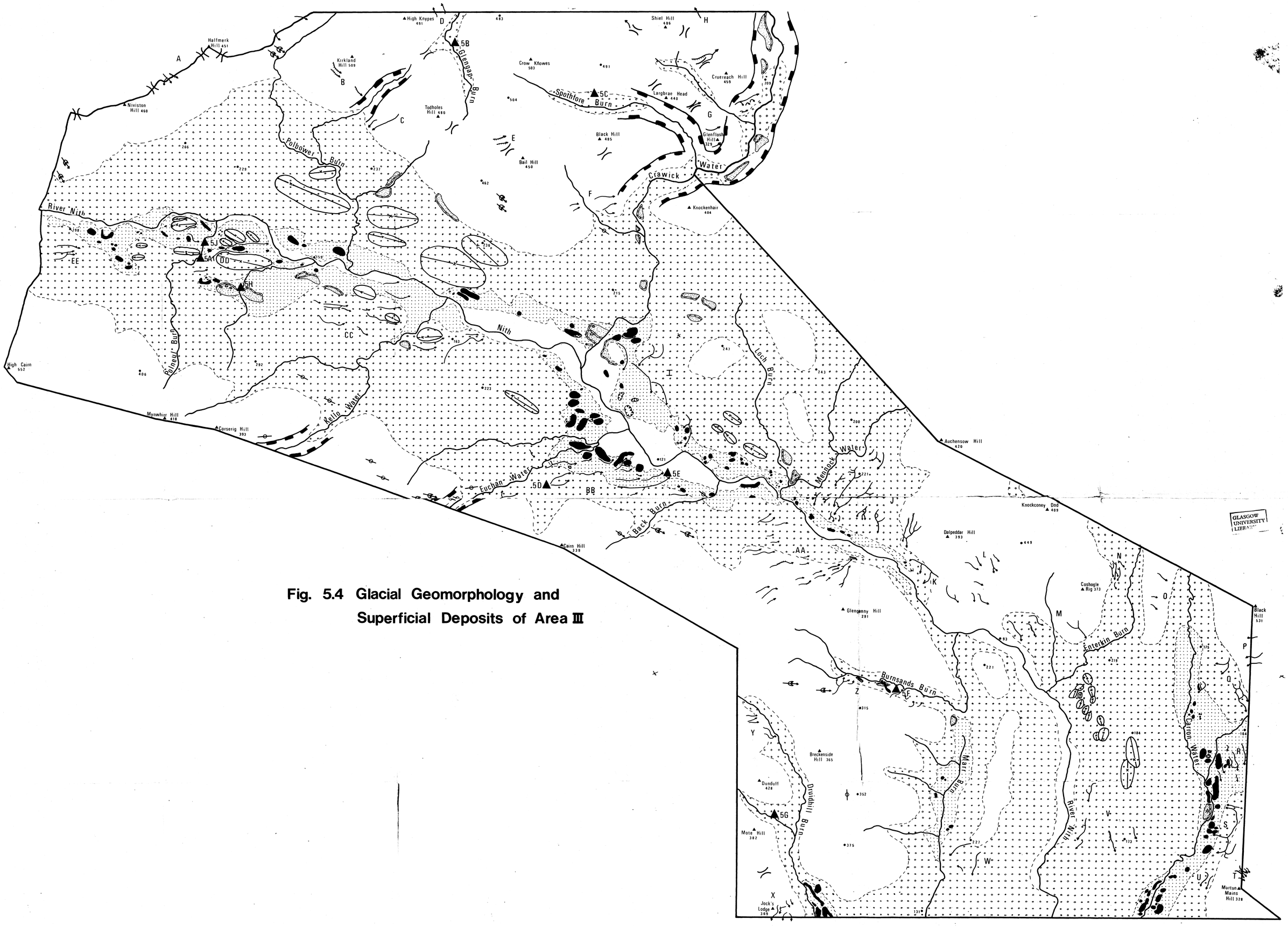
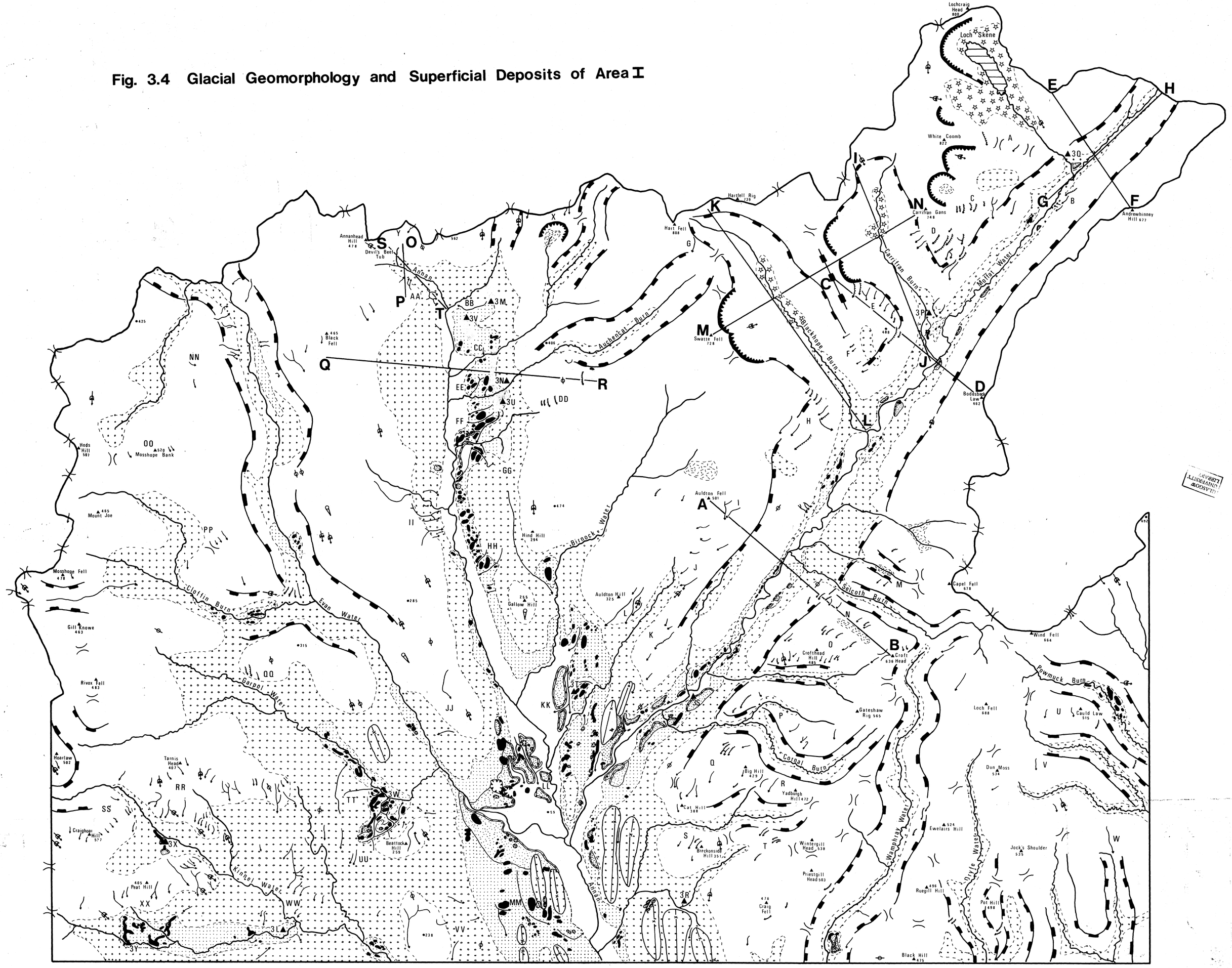


Fig. 5.4 Glacial Geomorphology and Superficial Deposits of Area III

Fig. 3.4 Glacial Geomorphology and Superficial Deposits of Area I



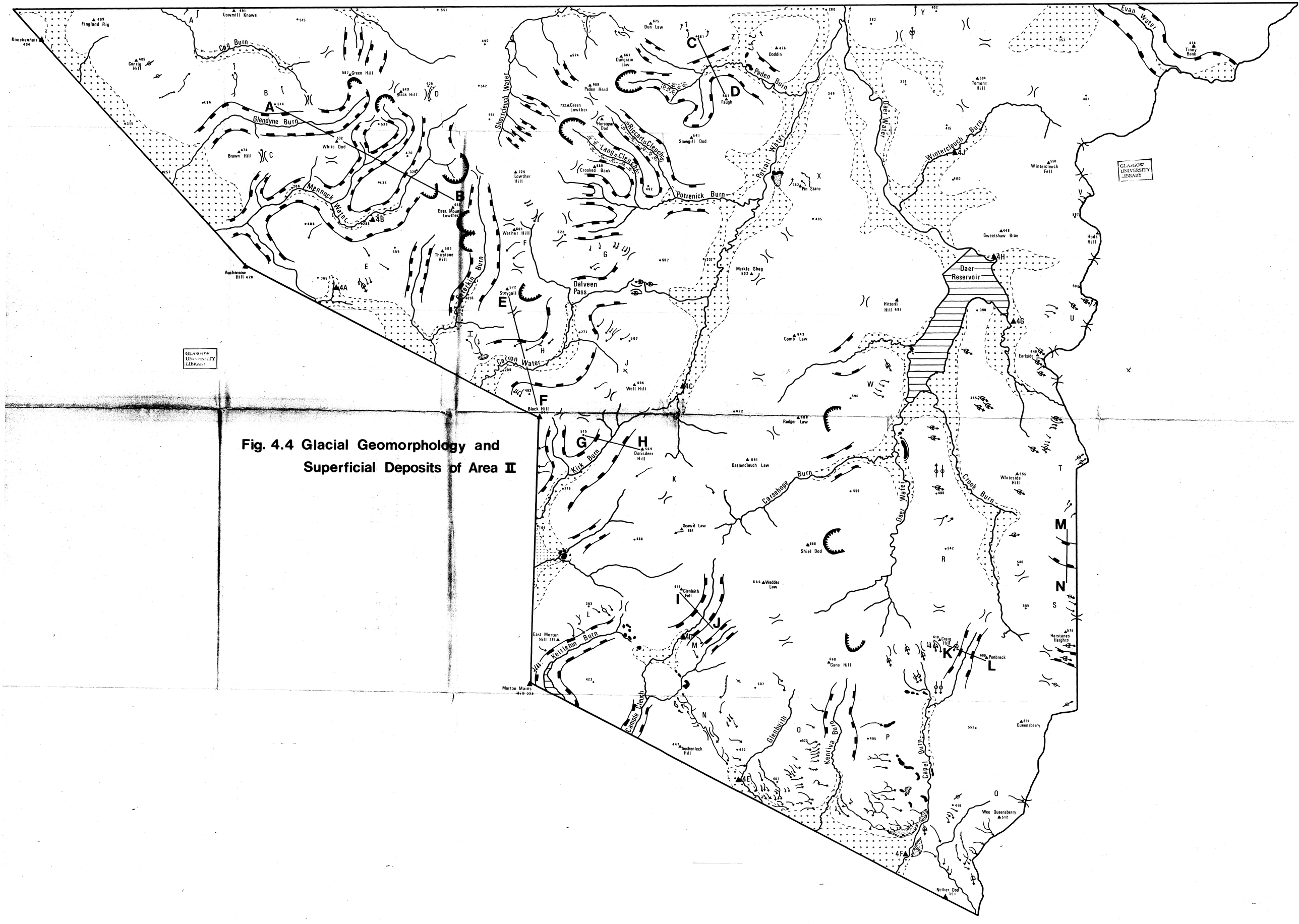


Fig. 4.4 Glacial Geomorphology and Superficial Deposits of Area II